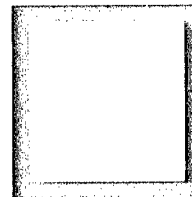


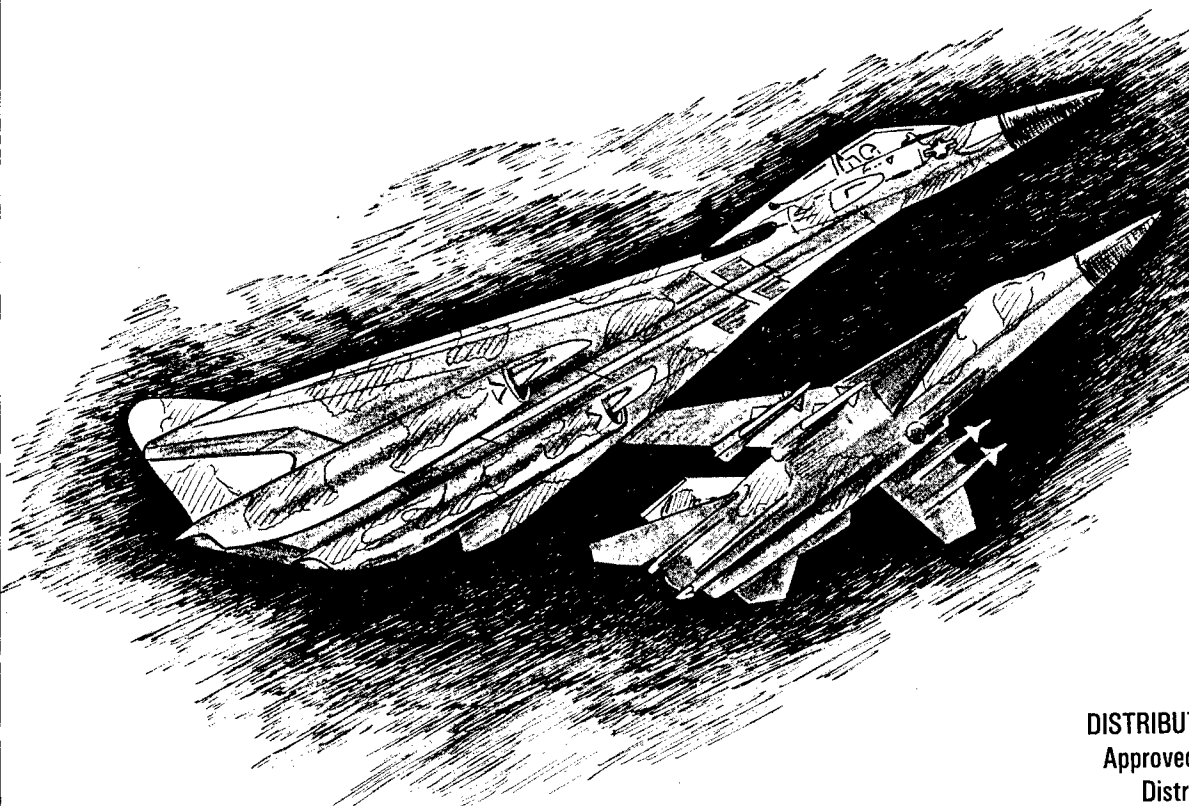
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AIR FORCE JOURNAL ^{of} LOGISTICS



**SUMMER
1985**



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RELIABILITY AND MAINTAINABILITY

**Squeezing Maximum Combat Availability from
New and Mature Weapon Systems**

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Air Force Journal of Logistics

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CONTENTS

ARTICLES

- 3 SPECIAL **Using Technology to Improve Readiness and Reduce Cost: Challenges for Contracting**
Lieutenant General Marc C. Reynolds, USAF
- 6 SPECIAL **Avionics Reliability—The War We are Winning**
Jerry D. Schmidt
- 9 SPECIAL **Institutionalizing Air Force Reliability and Maintainability (R&M)**
Colonel Gene S. Bartlow, USAF
- 13 SPECIAL **A Glossary of Reliability and Maintainability**
- 18 **A Manpower Impact Assessment Model for the Standard Base Supply System (SBSS)**
Captain Robert E. Burleson, USAF
Captain Larry D. Abney, USAF
- 21 **Depot Maintenance Spares Kit and the PRECOMP Model**
Major John T. Boeck, USAF
- 24 **Technical Order Acquisition Cycle**
Arthur A. Manguia
- 28 **Initiative: Improve System Support Readiness—How Serious Are We About Logistics?**
Major Richard B. Reeves, USAF

PRO/CON QUEST

- 32 **Assessment of Risk: A Technology Transfer Challenge**
Linda D. Brown
- 34 **Strategic Thinking and Logistics**
Lieutenant Colonel Kenneth N. Brown, Jr., USAF

DEPARTMENTS

- 16 *USAF Logistics Policy Insight*
27 *Career and Personnel Information*
30 *Current Research*
36 *Logistics Warriors*

Purpose

The *Air Force Journal of Logistics* is a non-directive quarterly periodical published in accordance with AFR 5-1 to provide an open forum for presentation of research, ideas, issues, and information of concern to professional Air Force logisticians and other interested personnel. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

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AFJL SPECIAL SECTION: R&M

In the history of weapon system design "buzzwords," *reliability* and *maintainability* may jointly hold the title for longevity. Preeminent among the long list of "ilities" that have worked their way into the fabric of weaponry, ebbing and flowing from system to system and budget to budget, reliability and maintainability have long exhibited the tenacious staying power of irrepressible ideas whose time had not quite come.

But that ambivalence is rapidly being replaced with a strong sense of urgency that our weaponry is out of synchronization with the demands of the modern battlefield. Studies such as the Air Staff's *Air Force 2000*, coupled with lessons drawn from the Falklands, Grenada, and worldwide pockets of "low intensity warfare," have placed a premium on weapon systems designed for flexibility, mobility, and survivability. Lean, austere operational concepts demand extremely reliable weaponry that is easily maintained with minimum, if any, support equipment and manpower. In this environment, reliability and maintainability are no longer nice-to-have "ilities"—they are absolute mission essentials.

Logisticians carry the heaviest responsibility in creating a reliable, maintainable force structure. This AFJL Special Section focuses on R&M accomplishments and challenges that lie ahead for the logistics community.

Our lead article is by Lieutenant General Marc C. Reynolds, Vice Commander, Air Force Logistics Command. In *Using Technology to Improve Readiness and Reduce Cost: Challenges For Contracting*, General Reynolds stresses a most important link in the R&M chain—communicating service needs to system developers and builders. Following this, Mr. Jerry Schmidt, Deputy Director of the AFLC Logistics Operations Center's Airlift Force Structure Directorate, summarizes recent avionics R&M advances and suggests fertile areas for concentration. Colonel Gene S. Bartlow of the Air Staff's Directorate of Operational Requirements then tackles the challenge of "institutionalizing" new R&M policies—converting them from rhetoric to reality. The section also includes an R&M glossary and excerpts from relevant policy statements and documents.



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, D.C.

SEP 17 1984

MEMORANDUM FOR ALL MAJOR COMMANDS-SEPARATE OPERATING AGENCIES/CC

SUBJECT: Reliability and Maintainability of Air Force Weapon Systems - ACTION MEMORANDUM

For too long, the reliability and maintainability of our weapon systems have been secondary considerations in the acquisition process. It is time to change this practice and make reliability and maintainability primary considerations.

Reliable weapon systems reduce life-cycle costs, require fewer spares and less manpower, and result in higher sortie rates. Similarly, maintainable weapons require fewer people and lower skill levels, and reduce maintenance times. Equally important, good reliability and maintainability improve the mobility of our forces—fewer people and less support equipment to deploy. They reduce dependence on airlift and prepositioning, while increasing our ability to generate sorties.

We must emphasize reliability and maintainability throughout the acquisition process—from requirements definition, through concept development, design, production, and acceptance. Everyone must insure reliability and maintainability requirements are met through every step of the process. Reliability and maintainability must be coequal with cost, schedule, and performance as we bring a system into the Air Force inventory.

Our efforts, however, should not be confined to new or future programs. Many current systems will be with us into the next century. We need to make modifications which provide proven increases in reliability and address specific problems of maintainability.

To institutionalize the Air Force commitment, Lt Gen Bob Russ and Lt Gen Leo Marquez are forming a working group of logisticians, operators, and acquisition specialists to develop an Air Force-wide action plan with specific recommendations and suspenses. This will be reported to us in early December.

In the meantime, insure your people pay the utmost attention to reliability and maintainability needs as they prepare requirements, review specifications, and devise strategies. We need our best effort across the Air Force on this issue.

Charles A. Gabriel
CHARLES A. GABRIEL, General, USAF
Chief of Staff

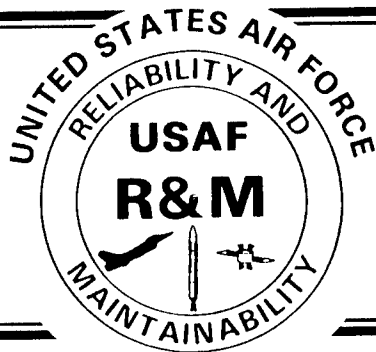
Verne Orr
VERNE ORR
Secretary of the Air Force

General Russ Gives Views on Reliability and Maintainability (R&M)

Lieutenant General Robert D. Russ, DCS/Research, Development and Acquisition, says: "The key to changing the way both the Air Force and industry think about reliability and maintainability is to back up our words with visible, tangible actions. These actions include the awarding of contracts, establishing incentives and fees and conducting thorough program and design reviews. Industry is capable of accelerating improvements in R&M if we demand it and support our commitment. Industry leaders have told us that 100% improvements in R&M are possible. Their experience shows we achieve a 30% improvement through learning and technology advances. Top management's attention can add another 25%, and conscientious applications of effective R&M design and manufacturing techniques will bring another 45%."

General Marquez Tells How to Improve R&M

Lieutenant General Leo Marquez, DCS/Logistics and Engineering, says we are witnessing the confluence of three great forces that can improve the reliability and maintainability of our weapon systems. He says: "First, digital avionics technology has progressed to the point where, properly focused, it can be its own salvation. In other words, it can now solve the very support problems it created. Secondly, the metallurgical durability needed by our current generation of engines has been developed. That should see the propulsion systems' resource demands diminish by half. And finally, there is a growing awareness that *operational* requirements must include *supportability* performance equal to or exceeding kill performance—that weapon systems that are available only *part* of the time effectively reduce your force structure by *significant* degrees. These three forces must be directed into discrete actions to produce operationally suitable weapon systems that will restore to airpower its most important characteristic: *flexibility that will permit force projection unhindered by the limits of infrastructure or airlift capacity*. We will make it happen not only because we can, but because we must."



Using Technology to Improve Readiness and Reduce Cost: Challenges for Contracting

Lieutenant General Marc C. Reynolds, USAF

Vice Commander

Air Force Logistics Command

Wright-Patterson AFB, Ohio 45433-5000

Introduction

I have followed discussions about contract management from several perspectives: the cockpit and the flight line, from the depot level to the research and development (R&D) arena, and now from the Logistics Command Headquarters where we ride herd on over 500 contracting actions per day. The conclusion is obvious; we need a modern, efficient, competitive industrial base that can produce high quality products, on time and at reasonable prices. We also need contracts which specify in plain English what it is we need—with a built-in set of incentives to reward good performance and help correct marginal performance.

A contract represents a meeting of minds. It builds a genuine understanding between buyer and seller. Quality products, solid delivery schedules, and a fair profit are the results of good contracts. I am encouraged by the progress that has been made in recent years. The partnership is working. We are aiming at most of the right targets. I would like to discuss a challenge facing all of us—one that is having a considerable impact on the logistics world. And that is, the Air Force drive to institutionalize and implement our reliability and maintainability (R&M) effort.

"Up-Front" Reliability and Maintainability

The best place to work R&M is at the front end of the acquisition program. That is where the payoff is—not after we go to production or later. All of us know life cycle costs get locked into a weapon system very early. By the requirement validation phase—even before we get the program go-ahead—approximately 80% of the life cycle costs have been committed. Actual expenditures at that time are still very low—less than 5% to 7%—but future spending has been pretty well locked up. That curve is familiar to everyone who has worked the trade-offs between cost, schedule, and performance.

In December 1984 the Air Force Acquisition Logistics Center (AFALC) completed a study, which reaffirmed earlier efforts, that looked at the system's life cycle, not in terms of cost, but in terms of the timing of the major decisions affecting life cycle expenses. The two curves are very similar in three ways:

- (1) By the end of the concept studies, 70% of the key decisions on the weapon system have been made.
- (2) By the end of system design definition, 85% of the decisions defining total life cycle cost are operative.
- (3) Ninety-five percent have been made by full-scale development.

When we consider that operation and maintenance account for the largest chunk of these life cycle costs, R&M considerations take on primary importance right from Day One of design. This fact of life has dramatically changed our outlook, and hopefully that of the aerospace industry. Poor reliability and maintainability mean that machines wear out soon, break often, and need frequent repairs. Support requirements—supply, maintenance, and transportation—for systems poorly designed in the context of R&M consume a lot of treasure. And yet we have lived in this kind of world for at least the last quarter century.

I am familiar with the industry view—and their pressing concern over their sources of profit from sales of spares and support equipment. That is a legitimate concern. But we must structure contracts so fair profits can be realized from developing more reliable systems. The higher the reliability, the better the maintainability, the higher the profit.

Gains to Date

We have been making progress. We have developed new tools: life cycle cost models, reliability equations, logistics support analysis, repair level analysis. We have learned a new vocabulary: producibility, preplanned product improvement. And we are seeing significant improvements in the indicators such as maintenance man-hours per flying hour (MM/FH):

F-16 MM/FH is about half that of the F-4.

F-15 is around a third less than the F-4.

B-1B will be 25% less than the B-52.

We are also realizing much higher reliabilities from subsystems and components. We have made progress in spite of a system that has traditionally not stressed, nor basically recognized, the full advantages of R&M. What we have done, in effect, is take advantage of better technology to improve R&M, as well as performance. When we retrofitted or redesigned a digital component to replace an analog computer, or even an electromechanical one, we exploited the technological state of the art.

Certainly, we are getting a lot of payoffs from refitting our current tactical and strategic aircraft fleets. The new radar antenna on the B-52G is now over 130 times more reliable than its predecessor. The previous radar antenna's mean time between failure (MTBF) had steadily decreased from an original figure of 230 hours in 1982 to 125.5 hours MTBF in late 1984. The new antenna is good for 16,510 hours MTBF. The B-52's newest electronic altimeter is now twice as reliable as the old one, due to new technology. The original altimeter had 387 hours MTBF; the new figure is 825 hours.

The F-111 fleet, a mature system, has been the object of a recent avionics modernization program. State-of-the-art technology has boosted performance and saved money as well. (See the following article, *Avionics Reliability - The War We're Winning* - Ed.) We not only get an increase in mission capability with these mods, but we also buy a lot more readiness and improve the probability of mission success.

Of course, on the newest operational aircraft, technology has made even more dramatic increases in R&M. The philosophy driving the F-15 program, particularly as it moves toward the F-15E model, will provide a number of success stories. The F-15C/D, the latest model in the field, routinely flies above its goal sortie rates. The fully mission capable (FMC) rates for the fleet generally run 12% above the Tactical Air Command's standard, and we are seeing some wings with FMC rates around 90%.

The development of the C-17 cargo aircraft also demonstrates the extent to which the concept of reliability, maintainability and availability (RM&A) can infuse total system design. For the C-17, the total system includes maintenance and support such as the support equipment and automatic test equipment and the aircraft itself. Using life cycle cost as a constraint, we have optimized design trade-offs between performance features of the system and its corresponding support requirements. This provision covers both government-furnished equipment (GFE) and contractor-furnished equipment (CFE). The contractor thus trades off cost, performance, and R&M earlier and at lower levels than ever before, but only to the extent that system requirements, such as high reliability on mission-critical subsystems, can be satisfied.

Designing to a life cycle cost in this manner sets a goal which includes not only acquisition but also out-year support expenses for the weapon system. Trade-offs must be made in this total context. What we have gained is the flexibility to spend money up front, during acquisition, to gain a later payoff in lower support costs. We had this approach incorporated into the C-17 from its initial design phases because it just made good sense. So, given the climate several years ago, we pressed R&M as hard as we could.

A Stronger Commitment

But now the rules have changed. Last September, in a joint letter, the Chief of Staff and the Secretary of the Air Force directed that R&M, and other elements of supportability, will become coequal objectives for every program, along with cost, schedule, and performance (see p. 2 for a reproduction of this letter). That directive sparked a major evolution which is gathering momentum daily. The Air Force is presently committed to emphasize R&M throughout the acquisition process and to institutionalize this commitment.

An Air Staff reorganization to establish the focus for a clear, strong R&M program has been implemented. In my opinion, all the appropriate organizations are now taking R&M very seriously, and we are moving to extend that pressure throughout every phase of the life cycle of our weapon systems. The Air Staff R&M Action Team visited AFLC Headquarters in early February and emphasized three essential R&M building blocks:

(1) Design R&M requirements must be stated clearly; that is, they must be *measurable, verifiable, and enforceable*.

(2) An effective contractual process must be developed which reflects these R&M requirements, and the contract *must*

contain incentives as well as warranties.

(3) R&M must be *emphasized during design and manufacturing*. This building block envisions provisions for an iterative, on-going, design process; periodic in-depth technical reviews; and realistic testing of the system.

A lot of USAF resources are about to be marshalled to support the action. In-house, you can expect top management to remain committed to the concept. Further, we are going to do our best to convince the industrial base that we are serious about this business. We immediately plan to:

Expand acquisition planning for R&M.

Improve R&M requirements in contracts.

Broaden R&M consideration in source selection.

Intensify R&M assessments in design reviews.

Upgrade use of R&M warranties and incentives.

Ensure that industry institutionalizes commitment.

All these actions are being implemented. Our slogan will be: "Lead, follow, or get out of the way."

Consider the potential benefits of a sustained, concentrated drive to enhance R&M across the board. Our inventory of tactical aircraft provides a case in point for R&M. The transition from the F-4 and A-7 to our modern fighter force, the F-15, F-16 and A-10, illustrates what can be accomplished, almost by accident.

Our newest air-to-air fighter, the F-15, contains avionics which are three times more reliable than those in its older counterpart, the F-4E. In the air-to-ground bombing role, the F-16 is four times more reliable than the old F-4D. Further, both the F-15 and F-16 are substantially more lethal than their immediate predecessors. Translated into war-fighting ability, these R&M enhancements have added approximately 4 more sorties to each F-15 and 5 1/2 sorties to each F-16, compared to the aircraft they replaced.

Let us examine the new F-15E model from the standpoint of R&M. The current F-15 fleet has approximately an 80% "mission capable" rate overall and a 65% "eight-hour fix rate." Our goal for the F-15E is to raise the "mission capable" target to 85% and to achieve an "eight-hour fix rate" of 80%. That works out to a 23% improvement per aircraft.

The message from Air Force, DOD, and Congress is that R&M is for real. Our game plan is to increase the front-end emphasis on R&M in the acquisition cycle and then scan the fielded weapon systems for potential modifications or changes in repair levels and support concepts. And we are doing both.

Incentives will be focused on R&M. Competing vendors will need to demonstrate R&M accomplishments both for the design and for the fielded system. The pieces are coming together very quickly. The concept is snowballing, and none of us can afford *NOT* to be pushing R&M.

In AFLC each of our weapon system program managers has been charged to produce a system engineering baseline and to look for R&M and other support problems. The AFLC/AFSC Productivity, Reliability, Availability and Maintainability (PRAM) office has been working for several years to explain some of our needs to industry and to help develop products that do the job better and cheaper. The Air Force Logistics R&D program has focused AFSC's laboratories on supportability issues.

Our need to improve R&M has been driven by the intensifying threat we face, coupled with a diminishing manpower pool and rising support costs. We now have the opportunity to make considerable gains, using the margin of technology that exists.

The support of all levels of leadership and management, as well as the capabilities and potential of the industrial base, can help us bring this worthwhile concept to fruition. By tackling

the R&M issue in all its facets, we will go a long way toward improving the capability of the Air Force to fly and fight.

AF

LOGISTICS REALISM IN EXERCISES

SOVIET OBSERVATIONS

The following excerpt was extracted from the Soviet Ministry of Defense monthly journal Voyennyy vestnik (Military Herald) and translated by the Air Force Intelligence Service (AFIS). In the complete text, Col G. Mokrousov describes an opposed-forces tactical exercise he recently observed and then reflects on what he considers a serious deficiency—a lack of realism in terms of logistical, engineering, medical, reconnaissance, and other “combat support” aspects of battle. This lack of realistic training, he asserts, results in serious problems under near-combat and combat situations.

The facts are sad but explainable: it is obvious that little attention was given in classes to practicing combat support topics. I also cannot help but state that this exercise seemingly was held apart from political work intended to explain the missions facing the units and to ensure the unconditional and tactically competent fulfillment of the combat decisions made by the commanders. And it was seemingly apart from the technical and logistical support which are aimed at servicing combat equipment and weapons, both before the beginning of combat operations and in their course, and at promptly replenishing the unit's ammunition, fuels, and lubricants.

This is apparently a case where the exercise director focused attention only on developing the commander's purely tactical skills and underestimated the importance of comprehensive combat support.

During the Great Patriotic War both senior chiefs and subordinates had great respect for those commanders who not only fought skillfully, but also organized with inspiration political work, reconnaissance, camouflage, engineer support, technical support, logistical support, and security; that is they had respect for those commanders who comprehensively supported combat operations. As a rule, such commanders won on the battlefield, and their subordinate units suffered fewer losses.

There is no question that it is the exercise director's job to create a combat-like environment throughout the exercise. In my view the component elements of this environment can be personnel “losses” from enemy fire as well as equipment and supply “losses,” and situations forcing commanders to perform constant reconnaissance of the enemy and to carry out steps for security, camouflage, and NBC defense. This not only will give commanders and personnel a true impression of modern combat, but it will also contribute to a growth in their combat proficiency.

FROM THE [SOVIET] EDITORS: The article by Col G. Mokrousov raised important issues of unit field training. It stands to reason that not all the author's opinions are indisputable, but in the main he is correct. We cannot count on high effectiveness of a tactical exercise if lessons of political work, reconnaissance, NBC defense, and engineer and chemical support are not worked on, or if proper attention is not given to technical and logistical support.

- Copyrighted, *Voyennyy vestnik*, 1984

R&M and the Logician

R&M begins as far back as the technology base worrying about R&M in the conceptual design process. R&M continues with well thought-out logistics parameters contained in statements of need and program management directives. Absolutely critical is translating those requirements into measurable and enforceable language that appears in the contractual documents. It continues with the contractors' design engineers being as concerned about the logistics parameters as they are about the performance parameters (logistics is a performance parameter). Similarly, testing that allows feedback into the design process and that verifies the contractor has lived up to the contractual requirements is essential to successful R&M programs. Moreover, guarantees and warranties properly applied play a large part in a good R&M program.

None of this is new—it's all contained in current publications. *What is needed is knowledgeable people committed to fielding supported weapon systems operating with iron discipline to raise the red flag when anyone tries to circumvent the process.* We need to help the process along . . . by knowing what constitutes a good R&M program at every point in the process . . . by doing our homework and having good rationale for what needs to go into the various documents . . . and by having the courage and discipline to stand up and be counted when proposed decisions weaken a system's R&M.

Major General Monroe T. Smith
Commander, Air Force Acquisition Logistics Center



Avionics Reliability—The War We Are Winning

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Wright-Patterson AFB, Ohio 45433-5000

Background

Operational requirements clearly have driven the complexity of weapon systems. With the introduction of the very complex F-111D in the late 1960s, the Air Force succeeded in building a weapon system with all weather capability and pinpoint accuracy. The basic problem, however, was the F-111D was a nemesis from an operational readiness standpoint. When operationally ready, it could hit the "whites of their eyes." However, the F-111D was plagued with reliability problems to the point it was of little value in accomplishing its assigned mission.

In the late 1960s, the Air Force Logistics Command (AFLC) began to build a management information system to assess weapon system reliability—the increased reliability of operational system (IROS)—which has since been designated the D0-56 system. The purpose of IROS was to assimilate and array worldwide Air Force maintenance data. Through this data, "bad actors" could be identified and management could focus attention on correcting the reliability of systems or subsystems that were preventing weapon systems from accomplishing their missions. In addition, IROS provided the tools needed to zero in on those systems or subsystems which should be replaced because of inordinately high life cycle costs (LCC).

Early uses of IROS data justified large across-the-inventory modifications that proved very cost-effective. The initial programs selected included an ultra high frequency (UHF) modernization program, a tactical air navigation (TACAN) modernization program, and an upgrade program for the APN-59B navigation weather radar used on cargo and tanker aircraft. Table 1 shows the dramatic results of these modification programs. The decrease in depot maintenance man-hours for just these three programs (394,000 man-hours per year) represents a cost savings of approximately \$20 million each year. That, of course, is only a small part of the equation. Considerable maintenance man-hour savings were also accrued in the operational commands and, more importantly, the operational readiness of the Air Force was significantly enhanced. The Air Training Command (ATC) provided an excellent example of the impact of the ARC-164 UHF radio modernization program. The T-37 aircraft, after being modified with the new radio, flew two years of training sorties before experiencing its first airborne abort because of UHF communications problems. By comparison, the older UHF radios usually caused several aborts each month.

The success of those three programs stimulated a continued expansion of the modification program to solve operational supportability problems. Very high frequency (VHF) radios, inertial navigation platforms, doppler radars, high frequency

(HF) radios, radar altimeters, VHF omnirange (VOR)/instrument landing system (ILS) systems, and transponders were added to the list of systems for upgrade through retrofit. The Air Force set its sights on high reliability for all *common* avionics systems; i.e., those used on more than one aircraft. There is a success story associated with each of the programs. More importantly, there has been a significant increase in the availability of aircraft using these avionics systems to support the operational commitment.

RESULTS OF MODIFICATION PROGRAMS			
	ARC-164 UHF RADIO	ARN-118 TACAN	APN-59 WX RADAR
RELIABILITY OF SYSTEMS REPLACED (MTBF)	30-100 HRS	100 HRS	18 HRS
CONTRACTED RELIABILITY (MTBF)	1200 HRS	800 HRS	N/A*
DEPOT MAN-HOUR REDUCTIONS (YEARLY)	178,000 TO 30,000	131,000 TO 15,000	216,000 TO 86,000
FIELD RELIABILITY NOW (MTBF)	1000+ HRS	1075 HRS	88-100 HRS

* ONLY SELECTED LRUs OF THE APN-59 WERE MODIFIED. THEREFORE, NO SYSTEM RELIABILITY WAS CONTRACTED FOR.

Source: AFLC Items Managers

Table 1.

In parallel with the efforts to identify avionics used on multiple aircraft, the Air Force started programs to upgrade many aircraft *peculiar* avionics systems. The F-111D analog signal transfer unit was replaced with a digital signal transfer unit resulting in a mean time between failure (MTBF) increase from 46 to 217 hours and an annual cost decrease from \$3.5 million to \$100 thousand. Concurrently, the F-111D electronic converter set was replaced with an advanced microelectronic converter set resulting in an MTBF increase from 39 hours to an incredible 1,447 hours and an annual cost decrease from \$1.2 million to \$100 thousand. The *major* effect of these modifications, however, was an increase in the fully mission capable rate from 22.5% to 42%. For a modification cost of \$40 million, the operational sorties available on a multibillion dollar investment had essentially doubled.

Systems Acquisition and Billion Dollar Retrofits

With all the gains being made through subsystem retrofits, the Air Force was still not realizing the large increases in total avionics reliability and availability that modern warfare requires. The obvious answer was to force industry to produce systems which could meet the rigorous requirements demanded of today's (and tomorrow's) battlefield without resorting to costly retrofits. Total avionics suites needed to be designed so upgrades could be accomplished without totally reengineering the system. At the same time, the low rate of

procurement of new weapon systems dictated greatly enhanced reliability and availability of selected older weapon systems. These systems also had to be designed to allow for future upgrades without again resorting to large retrofits.

Efforts began in the mid-seventies to develop standards which would accommodate the rapid acceleration of technology and minimize the costs of inserting that technology into weapon systems. These standards include a Multiplex Bus system (MIL-STD-1553B); a computer architecture (MIL-STD-1750A); a standard higher order language, Jovial J73 (MIL-STD-1589B), soon to be replaced with airborne data automation (ADA); a stores interface bus (MIL-STD-1760); and a standard automatic test equipment language (ATLAS). Form, fit, and function (F³) specifications were also used for the first time. This allowed new and innovative technology to be rapidly assimilated without redesigning entire weapon systems.

These standards were developed with the joint participation of government, industry, and academia. Waiver procedures were established and the enforcement efforts started. The initial resistance, which always occurs when constraints are applied, has now subsided. The Air Force is now insisting on, and industry is complying with, standards which will allow orderly change in the future.

The problem of major upgrades to older weapon systems was addressed through two avenues—modifications to add capabilities and to make the weapon system better capable of accomplishing its designed mission. Two examples demonstrate the two modification approaches: the offensive avionics system (OAS) on the B-52 and the avionics modernization program (AMP) on the F/FB-111.



First B-52G equipped with offensive avionics system (OAS) rolls out at Boeing, Wichita, 1 September 1980.

The OAS is a modification performed in conjunction with the addition of the Air Launched Cruise Missile to the B-52. The vacuum tube technology of the 1950s is being replaced with the solid-state technology of the late 1970s and early 1980s. The change in technology over that 20-year time frame resulted in far higher component reliability and single components (medium scale integrated circuits) that replaced tens and even hundreds of components of the 1950s vintage. Even though many new functions are being added by OAS, the resulting avionics reliability increase is dramatic; roughly 30% of B-52 avionics failures have been eliminated.

In contrast, the AMP was not designated to enhance the operational capability of the F/FB-111. The objective of the program was to replace obsolete subsystems with new technology subsystems performing like functions, but with greatly enhanced reliability. The anticipated gains in reliability for the FB-111 are shown in Table 2. Assuming the anticipated MTBF is realized, the operational impact is an increase of 29% percent in weapons on targets. The operational impact of modifying the tactical F-111s is an

anticipated 56% increase in target kills in the first ten days of a war. All of this should be achieved while reducing the annual operating cost by more than \$25 million.

FB-111 RELIABILITY		
	CURRENT *MTBF	***EXPECTED MTBF
INERTIAL NAVIGATION PLATFORM	5	786
TERRAIN FOLLOWING RADAR	9	50
ATTACK RADAR SYSTEM	11	50
SIGNAL CONVERTER	15	383
DOPPLER RADAR SYSTEM	17	2000
DISPLAYS	22	210
GENERAL PURPOSE COMPUTER	47	750
AUXILIARY FLIGHT REFERENCE SYSTEM	48	DELETED
RADAR ALTIMETER	72	2000
ASTRO COMPASS	96	DELETED
**COMBINED MTBF	1.56	19.61

* MEAN TIME BETWEEN FAILURE EXPRESSED IN FLIGHT HOURS.
 ** MEANTIME BETWEEN FAILURE OF ALL THE SUBSYSTEMS LISTED COMBINED.
 *** COMPARISON TO SIMILARLY FIELDIED SYSTEMS OR BY CONTRACT GUARANTEE.

Table 2.

Technology's Visible Gain

The Air Force continues to pursue technological superiority in its weapon systems. Each new system adds new capabilities and new challenges for the logistics system. From the time sophisticated radars and bombing navigation systems were added to aircraft after World War II, until the late 1960s, the added capabilities translated to reduced MTBF and thus reduced readiness. It was the introduction of integration circuits that finally caused MTBFs to increase. Table 3 shows the MTBF changes in fighter aircraft built over the last 25 years. Note that the low point was reached with the F-111s in the late sixties. Since that time, the overall MTBFs have steadily increased and the major contribution to that increase has come from the avionics equipment. Avionics built in the last five years account for only one aircraft failure in three, compared to two failures in three 10 to 15 years ago. (It is noteworthy that the older aircraft have been retrofitted with many of the across-the-inventory avionics modifications which have increased their avionics MTBF substantially. The 1983 data in Table 3 reflects all common avionics upgrades incorporated into the older aircraft.) The Air Force and the Department of Defense (DOD) are finally realizing the higher avionics MTBFs expected with the introduction of solid-state technology.

AIRCRAFT RELIABILITY					
1983 DATA					
WEAPON SYSTEM	*MTBF TOTAL AC	MTBF AVIONICS	MTBF NON-AVIONICS	% FAILURE DUE TO AVIONICS	% FAILURE DUE TO NON AVIONICS
F111D	.890	1.112	1.773	.620	.379
F111E	.860	2.176	1.422	.395	.604
F111A	.897	1.593	2.053	.563	.436
F106A	1.044	1.822	2.445	.573	.426
F111F	1.098	1.997	2.439	.549	.450
F4D	1.113	1.823	2.642	.610	.389
F4E	1.158	1.782	3.307	.650	.349
F4D	1.230	1.695	4.484	.725	.274
RF4C	1.333	2.223	3.330	.599	.400
F4C	1.357	2.821	2.615	.481	.518
F16B	1.765	4.426	2.936	.398	.601
F15C/D	1.905	3.886	3.737	.490	.509
A7D	2.119	4.218	4.258	.502	.497
F15A/B	2.299	5.497	3.952	.418	.581
F16A	2.785	7.293	4.453	.379	.620

* MEAN TIME BETWEEN FAILURE MEASURED IN FLIGHT HOURS.

Table 3.

The Future

The reliability of avionics should continue to increase rapidly as we assimilate the very high speed integrated circuit (VHSIC) technology currently being developed by DOD. The ability to reduce the number of connections on circuit boards, reduce cooling requirements, build in redundancy for critical failure paths, pinpoint failures through built-in-test, replace electromechanical devices with solid-state digital technology, reduce or eliminate the requirement for intermediate test stations, and build fail-soft systems (single failure does not degrade the system enough to notice) will all contribute to an increasingly capable and more reliable weapon system. Equipment built in the early 1990s will have avionics MTBFs considerably higher than the MTBFs of today's weapons. Further, the avionics percentage of the weapon system failures should drop to approximately 10% in the 1990s. This should occur even though more electronics will be added and the total system MTBF should improve significantly. All moving parts will be eliminated from inertial navigation systems as ring laser gyros replace spinning mass gyros. Radar antennas will no longer have moving parts as electronically steered arrays replace gimbaled systems. Large radar transmitters will be replaced with active elements in the array antenna. Stealth technology should reduce the need for high-powered electronic countermeasures transmitters.

Guarding Our 6 O'Clock

Many efforts, which have been started, must be continued if we are to realize our objectives of very high reliability:

(1) **Life Cycle Cost Procurements.** We must avoid going back to procurements where we look only at the price in selecting a contractor.

(2) **Warranties.** We must insist the contractor provide written guarantees, with penalties for non-performance, that what we contract for will be delivered.

(3) **Continued Leadership.** Air Force leaders must continue to keep pressure on program managers to ensure reliable and maintainable systems are fielded. They must continue to willingly trade "Bells and Whistles" for reliability and maintainability.

(4) **Balancing a High Reliability and Redundancy.** A proper balance must be achieved between high reliability and redundancy. Once we achieve a certain probability of mission success, we must avoid adding redundancy which will only add weight and increased sophistication.

(5) **Proper Cooling Design.** While heat generated to perform a function will decrease, heat within specific components will increase significantly. Care must be taken in designing these components into systems to ensure operating temperatures are not exceeded.

(6) **Improved Power Supplies.** Power supply designs will require significant improvements to prevent them from becoming the Achilles' heel of our new avionics armor.

(7) **Testability.** The ability to test systems that have hundreds of millions of responses to different combinations of inputs will challenge our brightest engineers and scientists. Digital systems with software reprogrammability have added great flexibility to the Air Force, but not without pain.

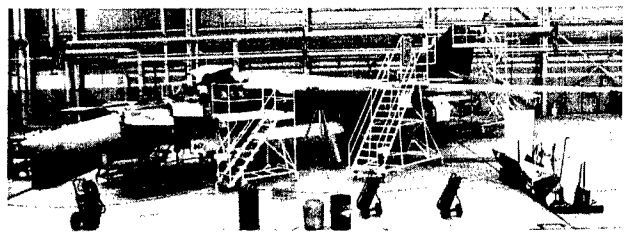
(8) **Software Must Be Partitioned.** Mission data needs and systems design often are written into the same programs. Confusion exists as what constitutes a configuration change and what is a data change.

Conclusion

The declining number of young people in the United States (US) will restrict military manpower to roughly its current size and may force manpower reductions in the 1990s. Battlefield conditions will dictate that we operate from dispersed locations under austere conditions. Our ability to fight and win will depend upon our will to fight and win and the capabilities of the equipment we provide to our forces.

The fruits of technologies being developed validate the continued push for technological superiority in lieu of numerical parity. The Air Force and the aerospace industry are meeting the challenge of building sophisticated systems and achieving high levels of readiness. The avionics reliability war is being won.

JP



FB-111A trial modification aircraft undergoing on-aircraft mock-up.

F-111 Avionics R&M

"The F-111 Avionics Modernization Program is an R&M modification which we expect to improve the MTBF of the bomb-navigation system ninefold. The built-in test (BIT) will substantially improve maintenance at the organizational level. Most important, this R&M effort will increase bombs on target by twenty-nine percent."

—Ron Fullmer
F-111 System Program Manager

Most Significant Article Award

The Editorial Advisory Board has selected "Variability of Demand: Why the Part is Never on the Shelf" by Major Douglas J. Blazer, USAF, as the most significant article in the Spring issue of the *Air Force Journal of Logistics*.



Institutionalizing Air Force Reliability and Maintainability (R&M)

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Introduction

Dispensing munitions on the right target at the right time is a primary strategic and tactical mission of the Air Force. Our ability to carry out this mission is a reflection of many factors that make up a total mission package. These include the number of sorties available, the weapon delivery capability and capacity of the aircraft, the number and quality of aircrew available, electronic countermeasures, mission escort, intelligence, and weather. My focus is on the sortie production contribution to mission effectiveness.

Conceptually different aircraft systems are designed for different types of missions; however, all systems strive routinely to generate the largest number of sorties per day as physically possible. The primary method of achieving more sorties is through designed-in reliability, maintainability, and supportability. But often during design, logistics support considerations take a back seat to new operational requirements in avionics, radars, power systems, and so on. Ironically, these enhancements may or may not contribute to increased sorties.

Since design capabilities of new weapon systems are determined during the acquisition process and design trade-offs are the ultimate responsibility of program managers, the thrust herein is to provide a different perspective of system effectiveness and suggest some solutions that could help system program managers ensure reliability, maintainability, and supportability requirements are translated into enforceable contracts and ultimately supportable weapon systems.

Capability and Availability

Effectiveness is a function of two primary factors: system (hardware and aircrew) capability (expressed in terms such as speed, altitude, payload, and turn capability) and availability (comprised of reliability, maintainability, and supportability). Achieving capable and available weapon systems is what the acquisition process is all about. The challenge in "reliability" is to reduce the amount of weapon system maintenance and servicing downtime, thus increasing the availability of systems for their assigned missions. The challenge in "maintainability" includes designing into weapon systems ease of maintenance, such as by precluding situations in which it takes much longer to gain access to a part that wears quickly than it takes to actually repair or replace it. The challenge in "supportability" includes designing into the weapon systems simpler support requirements—using common connectors for fuel, common ground equipment, or common external stores

and munitions and increasing the availability of spares, tools, or specialized equipment needed to ensure uninterrupted support.

Reliability and maintainability (R&M) directly contribute to system performance. The probability of a system functioning as specified for the duration of a mission is directly related to component reliability. Fewer failures, accompanied by more accurate diagnosis and fault isolation and reduced resource requirements during repairs, would substantially improve system availability. Improved availability would not only increase daily peacetime numbers of aircraft to support training requirements, but would also provide a better starting point for generation to a wartime footing and enhance the ability to sustain combat sortie rates. Of course, availability can also be improved by buying more spares or by employing exceptional maintenance procedures such as cannibalization and intensified maintenance activity. However, these "catch up" approaches have led instead to high support costs and budgetary shortfalls.¹

The costs of support personnel, equipment, and spare parts are also directly impacted by R&M. By improving reliability, system failures are reduced, thereby lessening the need for spares and maintenance actions. Improved maintainability can further reduce the number of spares and maintenance actions, while also reducing the need for special test equipment and personnel. Improved fault isolation through more accurate, reliable, built-in test capabilities and automatic test equipment can also decrease spares requirements, maintenance actions, and required skill levels. Through improvements in these areas, substantial savings can be realized in manpower, training, equipment, and facility costs.²

Every Air Force program manager will readily agree on the need for weapon systems that are reliable, maintainable, and supportable. The problem is how to achieve these goals and make programmatic trade decisions that positively impact logistics support (reliability, maintainability, and supportability).

Achieving Support Goals

The acquisition process requires identification of a requirement; a follow-through management system to track progress; a testing system to ensure the Air Force gets what it pays for; and an enforceable contract to ensure procured systems are reliable, maintainable, and supportable.

Weapon systems project offices (SPOs) and deputy program managers for logistics (DPMLs) are charged with primary responsibility for ensuring new weapon systems are in fact reliable, maintainable, and supportable. The difficulty

experienced by SPOs and DPMLs is translating the need into enforceable contracts. For example, one commonly used standard for defining a maintainability requirement is maintenance man-hours per flying hours (MM/FH). Low MM/FH would be the goal (Table 1 illustrates this approach with current tactical systems).

TYPE OF AIRCRAFT	STANDARD MM/FH-CY3
F-16A	31.7
A-10A	27.98
F-4E	62.18
F-4D	45.90
F-111D	85.36
F-111E	62.64

Source: FY80-83 Tactical Aircraft Supportability Comparison, AF/LEYYC, Pentagon, Washington, DC, April 1984 by Jerry Gregory.

Table 1.

Using MM/FH alone is difficult because the standard is ill-defined and to date is not contractually enforceable. Normally, MM/FH includes *all* direct maintenance man-hours and organizational and intermediate level maintenance required to support an aircraft system at a single base. The word *all* is far too general. Moreover, the maintenance man-hours calculation methodology at one major command (MAJCOM) or base may not be counted in the same manner as at another base, or from one aircraft weapon system to another, or even from one defense industry contractor to another.

Routine scheduled maintenance actions are required on virtually every weapon system. Therefore, a certain level of maintenance is designed into the system, some more than others, to ensure a degree of reliability. However, the unprogrammed, unscheduled maintenance actions present the greatest difficulty to maintenance personnel. Scheduled maintenance would be similar to a routine oil change and tune-up on an automobile, or even long-term normally anticipated maintenance such as changing tires, air filters, and brake linings. Unscheduled maintenance would be a broken oil line, water pump, or an axle on an automobile.

The problem in aircraft systems is how to identify unscheduled versus routine scheduled maintenance. One way is by tracking the mean flying hours between unscheduled maintenance (MFHBUM) which would more clearly identify the actual availability of an aircraft weapon system. To properly identify maintenance man-hours, both scheduled and unscheduled man-hours must be considered.

Another measuring device is that of system *availability*. We need a clearly understandable and enforceable standard or standards by which to identify actual aircraft availability in wartime. Currently, the Air Force is using the actual experience of various aircraft weapon systems to set availability standards; but, in new weapon systems, one can often only guess what the standard should be. The Air Force should specify *before* buying what the expected available sortie rates will be, especially for wartime planning purposes. However, we often buy an aircraft without knowing in advance how many sorties will be available daily in wartime.

Air Force regulations do not clearly define all these parameters. Statements of need (SON), system operational

capability statements, and program management directives (PMDs) do not routinely define meantime between failure (MTBF) or meantime between maintenance (MTBM) or the calculation methodologies used, although DPMLs and SPOs are tasked to ensure they are considered during aircraft design and operational test and evaluation (OT&E).

Enforceable and trackable standards and calculation methodologies are needed not only for the total system but also for each subsystem within an aircraft. For example, an MTBF needs to be established for the hydraulic system, the munitions dispensing system, the avionics system, the radar system, the crew-ejection system, the landing gear system, and the airframe. Each subsystem requirement should be stated and then a cumulative standard for both scheduled and unscheduled maintenance should be established for the weapon system.

Where will the SPO director, contractor, and DPML obtain these standards and methodologies? A primary source, of course, is from experience and requirements of older on-line weapon systems. However, this approach will be only partially adequate as new technologies surface and requirements of weapon system capabilities change significantly. Logisticians should have readily available studies and analyses—within recognized regulations and documents—that provide all the available historical criteria, standards, and methodologies, as well as actual capabilities of all current and past mainframe

R&M 2000

Reliability and maintainability (R&M) are critical elements of effective weapon systems. The Air Force has rapidly developed and applied new technology and, as a result, pushed the performance of our systems to new plateaus of capability. However, operational effectiveness also depends on our ability to successfully support these complex systems in ever more hostile environments. This intensified threat has put a higher premium on R&M. For this reason, the Air Force is committed to accelerating the improvement of R&M across our weapon systems.

Until now, our emphasis on R&M has been focused primarily on cost-efficiency considerations. Today, however, operational necessities and logistic support considerations such as mobility, vulnerability, and manpower limitations demand we rethink this focus and work for more rapid improvements in our weapon system R&M. Accordingly, at the direction of the Secretary of the Air Force and the Chief of Staff, the Air Force has implemented an action plan called *R&M 2000*. This plan was prepared to institutionalize that commitment to improved R&M. The action plan is aimed at ensuring R&M is considered across all our weapon systems and treated equally with cost, schedule, and performance.

To bring about these changes within the Air Force, *R&M 2000* concentrates on key management objectives. These objectives are aimed at supporting the senior-level commitment to R&M, convincing industry of the necessity of this commitment and focusing our manpower and program resources on institutionalizing this commitment. As part of this process, the Air Force programmed approximately 2% of its FY86 budget request for R&M initiatives. The majority of the funding is imbedded within many proposed research, development, test and evaluation (RDT&E), system acquisition, and product improvement programs. Approval of these proposed programs is essential if we are to accomplish our R&M objectives.

In summary, the *R&M 2000* plan has the commitment of all Air Force commanders. It will affect all our weapon systems, involve our best people, cut across all our functions, and capture the support of our contractors. We are fully committed to the success of this plan and look forward to your mutual support as we jointly institutionalize improved reliability and maintainability throughout the Air Force.

Brigadier General Frank S. Goodell

weapon systems and subsystems. With this master listing by functional area and subsystem, the logistics program requirements officer can compare the standards and more readily determine new achievable levels of reliability, maintainability, and supportability. In fact, it would also be beneficial to include standards from other services experience.

Establishing standards and requirements is but one step in the process. Whether or not standards are actually translated into availability depends on the management approach and control systems used in individual aircraft acquisition programs. Decisions left unanswered at the Air Staff or SPO/DPML level are made at a lower level or left up to a contractor. The failure to clearly establish requirements and to develop solid management systems to control programs will inevitably result in cost control and logistics problems later in the acquisition process.

A strong top-down approach is needed, which is where lessons learned from past mistakes can best be implemented. AFR 57-1, *Statement of Operational Need (SON)*, is where the process begins, and the new edition provides a clearer outline of this approach with somewhat more detailed programmatic requirements. Once a program has been accepted as a viable Air Force requirement, the program management directive (PMD) is developed. Unfortunately, PMDs do not normally incorporate all the requirements of the SON and system operational capability statements. Each iteration of program development should build upon each previous step in the process, ensuring nothing is lost in the translation. The PMD should be the *complete statement of work* from which aircraft weapon system procurement contracts are developed, although this procedure is *not* the norm in aircraft acquisition systems today. The PMD is often now merely an overview of management procedures, responsibilities, and priorities rather than a complete statement of system management requirements.

One would expect, for example, that an expression of a contractual value for reliability, indeed for any operational suitability characteristic, would follow and not precede the establishment of an operational standard. But that was not the case in the F-16 required operational capability (ROC). The rapid pace of the F-16 program as it moved from flight vehicle technology demonstration to weapon system development resulted in the F-16 ROC becoming a "backfill" document.³

The need to emphasize R&M requirements, starting with milestone zero and proceeding through the full-scale engineering development (FSED)/production process, is spelled out in DOD Directives 5000.40 and 5000.39. Reliability and maintainability program plans and their various elements are defined in MIL-STD-785 and MIL-STD-470. However, full implementation of these directives varies among different types of equipment and different weapon system programs. There is little doubt that systems with far greater R&M are achievable, but the overriding issue is the ability to hold together all the key programmatic aspects of the structure when faced with conflicting demands of funding, costs, schedule, systems performance, and political constraints.⁴

Often, development contracts do not reflect what the leadership and program managers at the various levels think the contractors' requirements should be. Thus, the best intentions of the best program managers are lost in the shuffle of documents from one level to another. Moreover, what is considered a priority in trade-off management decisions may not always be the same priority the senior level management believes should be stressed. In other words, unless the

AIR FORCE SPECIAL ASSISTANT FOR RELIABILITY AND MAINTAINABILITY ESTABLISHED

On 1 February 1985, Verne Orr, Secretary of the Air Force, and General Charles A. Gabriel, Chief of Staff of the Air Force, signed a charter establishing the Special Assistant to the Deputy Chiefs of Staff/Logistics and Engineering (L&E) and Research, Development, and Acquisition (RD&A) for Reliability and Maintainability. Brigadier General Frank S. Goodell was appointed as the Special Assistant for Reliability and Maintainability (R&M).

The organization's charter consolidates in the Air Staff the responsibility, authority, and expertise to guide the Air Force initiative to accelerate improvements in weapon systems R&M. General Goodell and his staff of ten action officers are responsible for implementing the *R&M 2000* action plan which makes R&M coequal with cost, schedule, and performance when the Air Force develops and modifies weapon systems.

General Goodell is tasked by the Secretary and Chief of Staff of the Air Force to:

- Act as advocate and focal point for Air Force R&M.
- Manage and implement the Air Force Action Plan (*R&M 2000*).
- Perform reviews and oversight of program R&M performance.
- Provide R&M technical support to the Air Staff Board and Air Force Council including advisability to proceed with programs.
- Establish and coordinate Air Force policy for R&M.

In signing the charter for this new organization, Secretary Orr said, "*R&M 2000* provides the strategy and management initiatives to achieve the Air Force's goal of increased power through higher levels of reliability and maintainability in all systems."

The Special Assistant for R&M is located in the Pentagon and the office symbol is HQ USAF/LE-RD. Call AUTOVON 225-1171 (Commercial (202) 695-1171) for further information.

requirements and priorities are clearly stated in each document in extensive detail, there is no guarantee they will be met when a weapon system is produced. The SPO and DPML must then aggressively pursue the stated integrated priorities and requirements. The charter and objectives must be quite clear to all, and senior management must periodically follow up to ensure the stated priorities and requirements are being properly executed.

In conjunction with this approach, a very close association must be established with the prime contractor, using devices such as award fee incentives and direct Air Force participation in more efficient manufacturing technology (MANTECH) developments supported by funds made available specifically to the SPOs and DPMLs for these purposes. Only then will the SPO and DPML be able to apply enough pressure to ensure their respective requirements are met.

Some will say this overview is again merely a restatement of how the Air Force acquisition system works now; so what is new? The fact is this is how well-run programs are *sometimes* managed. They are not the norm, as evident in various programs experiencing limited wartime supportability, low sortie rates, increased manpower requirements for new aircraft versus older models, increased intermediate level maintenance requirements, or excessive spares costs and requirements due to low system reliability. Fixing part of the problem is helpful but a whole new management thrust is needed to ensure the Air Force is provided cost-effective, reliable, maintainable, and supportable aircraft weapon systems. Until the management approach, requirements process, and inspection procedures are *fully institutionalized* and documented, acquisition problems and follow-on wartime availability difficulties will remain.

Recapping The Problem

The four parts of the problem are:

(1) System requirements are often vague and lack definition, leaving the resulting reliability, maintainability, and supportability standards to the judgment of contract design engineers.

(2) Program management documents are not sufficiently detailed, objectives and requirements are often lost when translated from one document to another, and priorities are not always in agreement between various agencies.

(3) Funds are not normally made available for the purpose of providing award fee incentives to specifically cover R&M system requirements.

(4) Inspection and audit management follow-up is sporadic and full top-down management reviews are often somewhat limited.

A comprehensive fix is required for a comprehensive problem. But one thing is certain, the weapon system availability problem will not improve in the short run without attention.

Recommendations

The following recommendations are proposed to solve the problems:

(1) Definitive requirements development standards should be established.

(a) Clearly defined and universally understood calculation methodologies and comprehensive definitions are required for mean flying hours between scheduled and unscheduled maintenance, maintenance man-hours per flying hour, maintenance man-hours per sortie, mean downtime, mean time between maintenance, maximum repair time, mean man-hours to repair, mean time between demand, mean time between critical failure, and the other applicable measurements relating to availability.

(b) Calculation methodologies and readily understandable definitions should be incorporated into a single all-encompassing regulation. (The glossary included in this *AFJL* is a first attempt at bringing together appropriate definitions. Methodologies developed must be applicable at base level, major command, and the contractor.)

(c) Reliability, maintainability, and supportability standards and criteria applied to all current and past mainframe weapon systems should be consolidated into one document outlining the historical capabilities and methodologies, including those for subsystems, used by all services to the extent available.

(2) A detailed management system approach with a full documentation process should be developed.

(a) A step-by-step, top-down management approach needs to be described in an all-encompassing regulation. Several applicable regulations need to be consolidated into a single Air Force management regulation.

(b) New management approaches need to be documented, aligning the various program systems documents and ensuring each successive product fully incorporates the previous listed requirements, management concepts, priorities, and controls.

(c) Air Staff, SPO, DPML, MAJCOM, and contractor relationships and responsibilities in the process need to be stated in the all-encompassing regulation.

(d) The PMD must specifically address in a regulation

F-15 Reliability and Maintainability— A Decade of Growth

Today's F-15 is a different aircraft from those delivered 10 years ago. The majority of the improvements in combat capability have resulted from reliability and maintainability (R&M) efforts. In a fleet of 700 F-15s, an R&M driven change of 1% in the full mission capable rate can put seven more aircraft in the air. The F-15 of 1985 is flying an average of 50% more missions per month per aircraft than 10 years ago. Today's F-15 goes two and one-half times longer between corrective maintenance actions. This improvement, coupled with reductions in troubleshooting and repair times, full spares funding, and aggressive spares management, has resulted in a full mission capable (FMC) rate which has almost doubled in 10 years. The F-15 FMC rate, which measures the percentage of time all possessed aircraft in the fleet have all systems fully operational, exceeds 75%. Some units have surpassed 80% for extended periods.

The FMC improvements are in part a result of aggressively seizing design and testing changes as an opportunity to insert a prioritized list of high payoff R&M initiatives. The F-15 Multi-Stage Improvement Program (MSIP) is a good example. The majority of improvements represent new capabilities or changes to computer technologies which allow future capability enhancements to be made more efficiently. From a logistics standpoint, MSIP has provided the opportunity to apply more rigorous testing environments which represent more accurately the operational environment and thus induce more representative failure modes. This testing philosophy requires fixes to be engineered into final designs. Because the parts used in line replaceable units (LRU) are more rigorously specified and screened, mean time between failure rates are better. Maintainability has also been enhanced by requiring built-in test in the modified LRUs to fault isolate to the circuit card level. This feature reduces testing time and eliminates test ambiguities. Positive fault identification lowers the rate of unnecessary maintenance. The F-15 MSIP also has a reliability incentive program to ensure achievement of acceptable levels of field R&M performance with cash incentives for further improvements. The F-15 program has incorporated other changes solely for R&M reasons. For example, an advanced environmental control system will lower operating temperatures. This promises to increase MTBF performance by 20%, producing a significant reduction in support costs for avionics as complex as those of the F-15.

All R&M improvements started under MSIP were continued in the F-15E. Dramatic cockpit display changes produced the most significant R&M improvements. The F-15E, although more complex and capable than today's F-15, is expected to show a 20% improvement in field reliability. It will be equipped with a ring laser gyro inertial navigation system which will give a tenfold increase in reliability and will come with a reliability improvement warranty. This system offers additional maintainability improvement in that 10 hours of field level testing on the current INS can be eliminated in a change to two-level maintenance.

Lieutenant Colonel Fredric L. Abrams
F-15 Deputy Program Manager for Logistics

and each PMD the priority of R&M relative to system performance, costs, schedule, and security.

(e) Management emphasis must be clearly documented demanding early incorporation of R&M requirements into engineering design—long before critical design review, but not later than immediately following initial program go-ahead.

(3) A specific funding profile should be required at the beginning of a weapon system development to clearly support growth and maturation of R&M through FSED and early production.

(4) A comprehensive weapon system acquisition inspection, audit, and management oversight follow-up and feedback system should be incorporated within one all-encompassing Air Force regulation.

(a) Air Force inspection requirements, criteria, and standards for the Air Staff, SPO, DPML, and MAJCOM

program managers need to be incorporated to ensure R&M requirements are followed in a consistent and effective manner.

(b) Air Force Audit Agency involvement, procedures, and program participation need to be clearly defined to ensure R&M requirements are followed in a consistent, effective, and efficient manner.

(c) Management reports (a feedback system) must be developed to cover all aspects of reliability, maintainability, and supportability.

(d) Program management review (PMR) requirements (oversight) must be specified, including areas to be discussed, management approach, priorities, program studies planned and in progress, participants, and frequency.

General James P. Mullins, former Commander, Air Force Logistics Command, at the Air Force Association National Symposium on Logistics, 7-8 October 1984, addressed the issue forcefully. He stated the increasing reliance on high technology systems, combined with the "come-as-you-are" nature of modern warfare, creates a circumstance in which:

... the tail, in the form of logistics, will more and more wag the dog. Logistics will increasingly become the single greatest impediment to having real combat capability. We'd better find a way to cope with this reality until we can ultimately remove this impediment, hopefully by removing the need for logistics itself. The notion of building systems that don't need logistics, except for consumables like fuel and munitions ... isn't pie in the sky. In fact, to a great extent, we already have this technology. The 2,000 hour MTBF is not a fantasy of the future—it's a reality today.⁵

Conclusion

The Air Force has recognized the need and made the commitment to institutionalize R&M in the weapon system

acquisition process. On 17 September 1984, the Honorable Verne Orr, Secretary of the Air Force, and General Charles A. Gabriel, Air Force Chief of Staff, signed an action memorandum setting up an Air Force Deputy Chief of Staff (DCS) Research, Development, and Acquisition and DCS Logistics and Engineering working group to develop an action plan. Some elements of the concepts outlined within this paper have also subsequently been recommended by the working group, although with a significantly different approach on the issue. The bottom line objectives, however, are similar.⁶

The future can be bright for high sortie-producing weapons with a commitment to systematically institutionalize the concepts outlined herein. The systems management approach and options selected by the Air Force will have a significant impact on the near-term success of the initiative. The institutionalizing concepts proposed in this paper could additionally prove highly beneficial in the short run and, most importantly, provide for the high degree of weapon system R&M the Air Force requires in the future. The upfront investment in time and money is worth the effort.

Notes

¹Hodgson, Maj Gordon M. "Reliability and Maintainability in the Air Force," *Air Force Journal of Logistics*, Summer 1984, pp. 10-13.

²Ibid.

³Stanley, W. L., J. Birkler, and C. Roach. "More Supportable Systems Through Requirements/R&E Process Improvements," Rand Corporation Working Draft #1757-AF, January 1983.

⁴Rivorie, J. R., P. F. Goree, H. B. Lyon, Jr., and R. A. Gundel. "IDA/OSD Reliability and Maintainability Study," Vol I, Institute for Defense Analyses, Report #R-272, November 1983.

⁵Ulsamer, Edgar. *Air Force Magazine*, "No Room for Amateurs in Combat Logistics," December 1983.

⁶SECAF and AF/CC, Action Memorandum, "Reliability and Maintainability of Air Force Weapon Systems," 17 Sep 84.



A Glossary of Reliability and Maintainability

1. **ACQUISITION PROGRAM.** A directed effort with the goal of providing a new or improved capability for a validated need. An acquisition program may include the development or procurement of systems, subsystems, equipment, munitions, or modifications (AFR 800-2).

2. **AIR FORCE SYSTEMS ACQUISITION REVIEW COUNCIL (AFSARC).** Secretary of the Air Force Order 20.6, 26 June 1976, established the AFSARC as the senior Air Force advisory council for providing recommendations on system acquisitions (AFR 800-2).

3. **AFSARC ASSESSMENT COMMITTEE (AAC).** The AAC serves as a constructive critic on program issues to be presented at each AFSARC. It ensures all presentations to the AFSARC are well balanced, from an overall Air Force perspective (AFR 800-2).

4. **AVAILABILITY.** A measure of the degree to which an item is in an operable and committable stage when a mission is required. Availability is dependent upon reliability, maintainability, and logistics supportability (AFR 800-18).

5. **AVERAGE SORTIE DURATION (ASD).** The total number of hours flown divided by number of sorties flown.

6. **BREAK RATE.** The percent of time expressed in hours that an aircraft returns from a sortie and requires corrective maintenance before it can be relaunched.

7. **CANN RATE.** Maintenance cannibalization actions removing parts, spares, or other equipment from one aircraft to be installed and used to improve the operational posture of another aircraft. Formula: # of CANNs/100 sorties.

8. **COMPATIBILITY.** The capability of two or more operational items/systems

to exist or function as elements of a larger operational system or operational environment free of mutual interference (JCS Pub. 1).

9. **CONCEPT OF OPERATIONS.** A verbal or written statement, in broad outline, of a commander's assumptions or intent in regard to an operation or series of operations. The concept of operations frequently is embodied in campaign plans and operation plans, in the latter case particularly when the plan covers a series of connected operations to be carried out simultaneously or in succession. The concept is designed to give an overall picture of the operation. It is included primarily for additional clarity of purpose and is frequently referred to as a commander's concept. It is not related to a Preliminary/System Operational Concept (SOC) (JCS Pub. 1).

10. **DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL (DSARC).** The DSARC, as the highest level DOD corporate body for system acquisition, provides advice and assistance to the Secretary of Defense (DODI 5000.2).

11. **DORMANT RELIABILITY.** Probability that an item will remain failure-free for a specified period of time in a non-operating mode under stated environmental conditions (AFR 800-18).

12. **FAILURE.** The event or inoperable state in which any item or part of any item does not or would not perform as previously specified.

13. **FAULT DETECTION.** Determining the immediate cause of failure; e.g., maladjustment, misalignment, defect, etc.

14. **FAULT ISOLATION.** The process of determining the location of a fault to the extent necessary to effect repair.

15. **FAULT ISOLATION TIME.** The mean time to test and/or fault-isolate a

spare or line replaceable unit (LRU). This mean time is the total number of hours required to test and/or fault-isolate those LRUs. This includes system maintenance test equipment set-up or reconfiguration time.

16. **FULL MISSION CAPABLE (FMC) RATE.** The percent of hours aircraft are capable of performing all of the assigned missions (AFR 800-18).

17. **FIX RATE.** The percent of time expressed in hours that aircraft are designated not mission capable (NMC) but are repaired within eight hours after landing.

18. **INITIAL OPERATIONAL CAPABILITY (IOC).** The first attainment of the capability to effectively employ a weapon, item of equipment, or system of approved specific characteristics, and which is manned or operated by an adequately trained, equipped, and supported military unit or force (JCS Pub. 1).

19. **INTEGRATED LOGISTICS SUPPORT (ILS).** A composite of all the support considerations necessary to assure the effective and economical support of a system for its life cycle. It is an integral part of all other aspects of system acquisition and operation (JCS Pub. 1).

20. **INTEROPERABILITY.** The ability of systems, units, or forces to provide services to, and accept services from, other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together (JCS Pub. 1).

21. **LIFE CYCLE COST (LCC).** The total cost of an item or system over its full life. It includes the cost of development, acquisition, ownership (operation, maintenance, support, etc.) and, where applicable, disposal. To be meaningful, an expression of life cycle cost must be placed in context with the cost elements included, period of time covered, assumptions and conditions applied, and whether it is intended as a relative comparison or absolute expression of expected cost effects (AFM 1-1, Volume I).

22. **LIMITED PRODUCTION.** The initial, low rate production of a system in limited quantity to be used in operational test and evaluation (OT&E) for verification of production engineering and design maturity and to establish a production base prior to a decision to proceed with production.

23. **MAINTAINABILITY.** A characteristic of design and installation which is the probability that a system or component will conform to its designed conditions of use within a given period of time when maintenance is performed. The period of time is expressed in terms such as man-hours per flying hour, clock hours to complete, hours-to-troubleshoot, or hours-to repair (AFR 80-5).

24. **MAINTENANCE CAPABILITY.** Availability of those maintenance resources (facilities, tools, test equipment, drawings, technical publications, trained maintenance personnel, engineering support, and spare parts) needed to carry out maintenance.

25. **MAINTENANCE CAPACITY.** A measure of maintenance capability, usually expressed as the amount of direct labor man-hours that can be applied by an industrial shop or other entity during a 40-hour week (one shift and 5 days).

26. **MAINTENANCE CONCEPT.** An initial description of maintenance considerations and constraints submitted as a part of the acquisition process. It is introduced for design consideration, refinement, and revision in the concept exploration phase of each new system, equipment or modification. When refined and definitized, it becomes a Maintenance Plan (AFR 66-14).

27. **MAINTENANCE DOWNTIME PER SORTIE.** For a specified period of time, the total time the system is NMCM and NMCB, scheduled or unscheduled, in clock hours divided by the number of sorties (AFR 800-18).

28. **MEAN TIME BETWEEN CORRECTIVE MAINTENANCE ACTIONS (MTBMA).** Average time between maintenance actions expressed in hours excluding all general support; i.e., scheduled inspections, pre/post flight, loading, servicing, and preventive maintenance.

29. **MAINTENANCE MAN-HOURS PER FLYING HOUR (MM/FH).** The base level direct scheduled or unscheduled maintenance man-hours to support an aircraft system including preventive or corrective, on equipment, off equipment, and general support divided by the numbers of hours flown, but excluding the loading, servicing, and handling portion of general support. Formula: $MM/FH = ON/EQ + OFF/EQ + GEN/SUPP$ - hours flown.

30. **MAINTENANCE MAN-HOURS PER SORTIE (MM/S).** The base level direct maintenance man-hours to support an aircraft system divided by the number of sorties, excluding loading, servicing, and handling portion of support general. Formula: $MM/S = ON/EQ + OFF/EQ + GEN/SUPP$ - sorties.

31. **MAJOR SYSTEM ACQUISITION (MSA).** A system acquisition program designated by the Secretary of Defense to be of such importance and priority as to require special management attention. These programs commonly exceed \$200M RDT&E, and/or \$1B in procurement costs (DOD 5000.1).

32. **MEAN DOWNTIME (MDT).** Average elapsed time between loss of mission capable status and restoration of the system to mission capable status (AFR 800-18).

33. **MEAN MAN-HOURS TO REPAIR (MMR).** Total corrective base level man-hours divided by the total on equipment corrective maintenance events for a given period of time (AFR 800-18).

34. **MEAN MISSION DURATION (MMD).** Average interval of time over which a space system is expected to operate without mission failure (AFR 800-18).

35. **MEAN TIME BETWEEN CRITICAL FAILURE (MTBCF).** The average time between failure of essential system functions (AFR 800-18).

36. **MEAN TIME BETWEEN DEMAND (MTBD).** Measure of the system reliability parameter related to demand for logistic support: The total number of system life units (e.g., flying hours, sorties, etc.) divided by the total number of item demands on the supply system during a stated period of time (AFR 800-18).

37. **MEAN TIME BETWEEN MAINTENANCE (MTBM).** Total life units (for example, operating hours, flight hours, rounds) divided by the total number of maintenance (base level) hours for a specific period of time (AFR 800-18).

38. **MEAN TIME BETWEEN MAINTENANCE (INDUCED).** Average time between the on-equipment corrective events associated with malfunctions resulting from other than internal design and manufacturing characteristics, for example, improper maintenance, operator error, foreign object damage, failures due to malfunction of associated equipment (AFR 800-18).

39. **MEAN TIME BETWEEN MAINTENANCE (INHERENT).** Average time between the on-equipment corrective events associated with malfunctions resulting from internal design and manufacturing characteristics (AFR 800-18).

40. **MEAN TIME BETWEEN MAINTENANCE (NO DEFECT).** Average time between the on-equipment corrective events associated with equipment which have no confirmed malfunction, such as removals which subsequently bench check satisfactory (AFR 800-18).

41. **MEAN TIME BETWEEN MAINTENANCE (PREVENTIVE).** Average time between maintenance events including removals, replacement, or reinstallation associated with scheduled maintenance for time changes (AFR 800-18).

42. **MEAN TIME BETWEEN REMOVAL (MTBR).** Measure of the system reliability parameter related to demand for logistic support: The total number of system life units divided by the total number of items removed from that system during a stated period of time. This term is defined to exclude removals performed to facilitate other maintenance and removals for TCTOs (product improvement) (AFR 800-18).

43. **MEASURE OF EFFECTIVENESS.** A quantitative, or qualitative measure of a system's performance, or characteristics, to which it performs a task, or meets an objective under specific conditions.

44. **MISSION CAPABLE.** The percent of hours aircraft are capable of performing at least one (possibly all) of the assigned missions. Formula: $FMC + PMC$.

45. **OPERATING COMMAND.** The command or agency primarily responsible for the operational employment of a system, subsystem, or item of equipment. May also be referred to as using command (AFR 800-2).

46. **OPERATING CONCEPT.** A statement about intended employment of a weapon system that provides guidance for posturing and supporting combat forces. Standards are specified for deployment, organization, basing, and support from which detailed resource requirements and implementing programs can be derived. Generally, this type of concept addresses a generic capability or a weapon system that is non-major in magnitude and importance. Operational concepts should not be confused with PSOC/SOC documents which require HQ USAF approval (AFM 11-1).

47. **OPERATIONAL LEVELS OF PERFORMANCE.** An operating/using command's stated quantitative or qualitative performance requirements for a system against which results of test and evaluation can be compared.

48. **OPERATIONAL RELIABILITY AND MAINTAINABILITY.** A measure of merit that encompasses reliability, maintainability, or availability expressed in

operational terms that include the combined effects of item design, quality, installation, environment, operation, maintenance, repair, funding, and management policy (AFR 800-18).

49. **OPERATIONAL TEST AND EVALUATION (OT&E).** Test and evaluation conducted to estimate the system's military utility, operational effectiveness, and operational suitability (AFM 11-1).

50. **PARTIAL MISSION CAPABLE (PMC) RATE.** The percent of hours aircraft are capable of performing one or more but not all of the assigned missions (AFR 800-18).

51. **PARTICIPATING COMMAND.** A command or agency designated by HQ USAF to support and advise the implementing command during a development/acquisition program (AFR 800-2).

52. **PERFORMANCE REQUIREMENTS: THRESHOLDS AND GOALS.**

a. **THRESHOLD.** Minimum level of acceptable performance or capability.

b. **GOAL.** The upper level of system performance or capability that provides a desired enhancement.

53. **PRELIMINARY SYSTEM OPERATIONAL CONCEPT (PSOC).** Similar to a SOC, but prepared earlier in the acquisition cycle when specific quantitative and qualitative factors and parameters may not be readily available. PSOC documents usually evolve into a SOC as an acquisition program matures.

54. **PRE-PLANNED PRODUCT IMPROVEMENT (P³I).** An evolutionary approach designed to minimize technological risk and shorten time required to field new weapon systems. The approach envisions deliberate planning for use of less advanced technologies after the system has been placed in operation.

55. **PRODUCIBILITY.** The composite of characteristics which, when applied to equipment, design, and production planning, leads to the most effective and efficient means of manufacturing systems.

56. **PROGRAM MANAGEMENT DIRECTIVE (PMD).** The official HQ USAF management directive used to provide direction to implementing, operating, supporting, and participating commands and satisfy documentation requirements, request studies, and initiate, approve, change, transition, modify, or terminate programs. The content of the program management directive, including required HQ USAF review and approval actions, is tailored to the needs of each individual program.

57. **RELIABILITY.** The probability that a system or equipment will perform a required function under specified conditions, without failure for a specified period of time, or a given point in time (AFR 800-5).

a. **LOGISTICS RELIABILITY.** A measure of a system's ability to operate as planned under defined operational and support concepts using specified logistics resources.

b. **MISSION RELIABILITY.** A measure of the ability of a system to complete its planned mission or function.

58. **SORTIE GENERATION RATE.** Number of sorties that can be flown per aircraft per day under specified operational and maintenance concepts (AFR 800-18).

59. **REQUIREMENTS REVIEW GROUP (RRG).** A HQ USAF general officer review board which reviews, evaluates, and recommends validation for new or improved operational capabilities.

60. **STATEMENT OF NEED (SON).** A formal numbered document used to identify an operational deficiency and state the need for a new or improved capability for USAF forces (AFR 57-1).

61. **SUPPORTING COMMAND.** The command assigned responsibility for providing logistics support. It assumes program management responsibility from the implementing command (AFR 800-2).

62. **SURVIVABILITY.** The capability of a system to avoid or withstand a hostile environment and still accomplish its designated mission (AFM 11-1).

63. **SYSTEM.** All of AF weapon systems, subsystems, equipment, support equipment, and munitions (AFR 800-18).

64. **SYSTEM ACQUISITION PROCESS.** A sequence of specified decision events and phases of activity directed to achievement of established program objectives in the acquisition of systems. It extends from approval of a requirement through successful deployment of the system or termination of the program.

65. **SYSTEM DESIGN CONCEPT.** An idea expressed in terms of general performance, capabilities, and characteristics of hardware and software oriented either to operate or to be operated as an integral whole in meeting a mission need (OMB Circular A-109).

66. **SYSTEM OPERATIONAL CONCEPT (SOC).** A formal document that describes the intended purpose, employment, deployment, and support of a specific system. It assists in identifying the quantitative and qualitative performance and support specifications needed to satisfy the operational need and provides initial guidance to operating forces for employing the new or improved system. Specified are standards of deployment, organization, basing and support from which detailed resource requirements and implementing programs can be derived. It must be compatible with long-range Air Force goals and objectives and consistent with Air Force strategy, force structure, concepts for the future employment of aerospace forces, and current and emerging doctrine.

67. **SYSTEMS PROJECT OFFICE (SPO).** The organization within the implementing command comprised of technical, business management, and administrative personnel assigned full time to a system program director. The office may be augmented with additional personnel from participating organizations to manage the development and procurement of a system (AFR 800-2).

68. **SYSTEM SAFETY.** The optimum degree of safety within the constraints of operational effectiveness, time, and cost, attained through specific application of system safety engineering throughout all phases of a system (AFM 11-1, Volume I).

69. **SYSTEM TRAINING CONCEPT.** A document summarizing ATC training policy based on review of a user's requirements and planning factors reflected in the system operational concept and updates. It outlines conceptual guidance on test and evaluation and deployment training planning efforts. The basis for future training planning actions are documented in the system training plan.

70. **TEST.** Any program or procedure designed to obtain, verify, or provide data for the evaluation of research and development (other than laboratory experiments), progress in accomplishing development objectives, or performance and operational capability of systems, subsystems, components, and equipment items.

71. **TESTABILITY.** This element is determined by the capability to detect and isolate the faults in aircraft on or off equipment. The capability to detect and isolate faults on the aircraft is dependent on the design built-in test sensor capability and fault detection/isolation features of test systems, automatic or manual test support equipment and technical data.

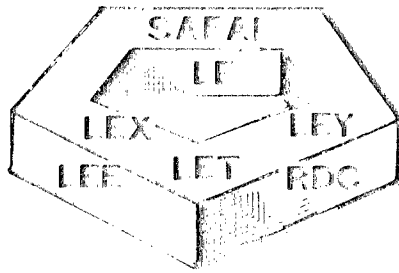
72. **WEAPON SYSTEM.** A final combination of subsystems, components, parts, and materials that make up an entity used in combat to destroy, injure, defeat, or threaten the enemy.

73. **WEAPON SYSTEM RELIABILITY (WSR).** The probability that a system will complete a specified mission, given that the system was initially capable of performing that mission. WSR is a measure of system reliability as it affects the mission, but excludes factors such as probability of kill, circular error probable, and other measures of capability (AFR 800-18).

(Glossary compiled by Colonel Gene S. Bartlow)

Supply Officers Guide

The Directorate of Maintenance & Supply (HQ USAF/LEYS) has recently published a *Supply Officers Guide* which is aimed at new supply officers, but is beneficial to all supply personnel. The Guide will help these officers plan their career and choose the right training and education to progress in their jobs. It also offers many tips in the areas of inspection, preparation for meetings, leadership, and management. This is yet another valuable contribution to making "The Year of Supply" an unqualified success. (If you are interested in obtaining a copy, please contact HQ USAF/LEYS, Washington DC 20330-5130.)



USAF LOGISTICS POLICY INSIGHT

New Supply Policies

During the past six months, much emphasis has been placed on managing government property. As a result, the Air Force has recognized that some previous policies and procedures were complex and difficult to implement. The result was misunderstanding and, at times, inappropriate disposal of government property. AFR 20-14, *Management of Government Property in Possession of the Air Force*, has been published to emphasize the responsibilities of all Air Force employees. In addition, major revisions have been made to AFR 67-23, *Standard Base Supply Customer's Guide*, and Air Force supply policies and procedures to simplify processes for obtaining, storing, retaining, and turning in materiel. Major savings have already materialized through repair and reutilization of materiel that may have been previously discarded. In addition to the dollars saved, improvements in readiness and support should result from the increased availability of spare parts.

Replacement of SRUs

The Air Force is introducing the next generation of avionics/electronics into both current aircraft (F-15 and F-16) and future aircraft (ATF and C-17). Today's electronics are hosted in line replaceable units (LRUs), which are made up of shop replaceable units (SRUs). SRUs may partition functions differently, be uniquely sized, require peculiar connectors, and need unique types of stand-alone test equipment. The advent of line replaceable modules (LRMs) will make such problems a thing of the past. By employing the Air Force Wright Avionics Laboratory's Pave Pillar very high speed integrated circuit (VHSIC) based concept, the expensive (in terms of types of people, test equipment facilities, power, etc.) electronic components can be replaced by standard LRMs. The form, fit, function, and interface of the LRMs will be specified by the Air Force. Any manufacturer who can produce LRMs that meet the standard will be placed on the qualified products list (QPL). Since LRMs will be required to contain all stimulus and measurement capability necessary to indicate their ability to function, the need for separate support equipment will be drastically reduced or possibly eliminated. The Air Force will procure interchangeable LRMs, allowing continual, multiple sourcing on a competitive basis. Because LRMs will have to employ VHSIC to ensure a function is restricted to a module, reliabilities should be extremely high. Future avionics systems will be built using government qualified LRMs as the system building blocks. Because the number of modules will be finite, LRM capabilities will be shared in a fashion similar to that used by ground based computers, which time-share resources. The net result of the new generation of avionics/electronics hosted by LRMs will be systems that are more reliable and maintainable. Additionally, these systems will be competitively procured throughout the life cycle of weapon systems that use them.

Enhanced Fuel Distribution

PETROL FLOW is an Air Force Engineering Services Center (AFESC) initiative to upgrade, modify, and expand fuel distribution (bulk storage and hydrant refueling) facilities. Many fuel systems are 30 or more years old and upgrading is expected to extend the life of these facilities for 20 or more years. Modifications and expansions to fuel systems will be designed to improve support for today's aircraft and those flown, well into the twenty-first century. HQ AFESC has published a booklet, *Liquid Fuel Facilities Evaluation Guide*, DEM-TR-85-01, dated May 1985, that provides guidance on implementing PETROL FLOW.

PETROL RAM is a Data Systems Design Office (DSDO) project to further automate fuels accounting. A prototype test is being planned for FY86 that will use a small computerized chip in lieu of an AVFUELS serv-o-plate (credit card) to provide aircraft type, model series, home base address information, and type fuel required for aircraft. The chip will be attached to the aircraft and be read by a computer device attached to the refueler. Expected results are improved accounting accuracy and a reduction in manually prepared paperwork.

Logistics Career Development Plan

At the April Air Force Logistics Conference, Lieutenant General Leo Marquez, Deputy Chief of Staff, Logistics and Engineering, HQ USAF, officially unveiled the Logistics Career Development Plan (LCDP). The Air Staff developed this plan to resolve an on-going problem within the logistics officer community. The Air Force does a good job of developing logistics specialists (aircraft maintainers, suppliers, etc.), but has not produced a sufficient number of generalists—logistics leaders who have experience in more than one logistics Air Force specialty command (AFSC) and who can make decisions and lead people based on that broader foundation of knowledge. The LCDP will rectify this by crossflowing some logisticians from their home-base specialty to second logistics AFSCs at specific points during their careers. (The upcoming Fall *AFJL*, featuring logistics professionalism and education, will contain more information on this program - Ed.)

CEMAS Implementation

Base civil engineers strive for optimum logistics support and the ability to better manage the real property maintenance materiel inventories under their control. To help accomplish these goals, the Civil Engineering Materiel Acquisition System (CEMAS) was developed. From 1982 through 1984, CEMAS was prototyped and tested at Tinker AFB, Oklahoma. After the test phase was successfully completed, HQ USAF/LEE/LEY/RDC approved CEMAS in January 1985 as the standard support system for civil engineering. As part of the Civil Engineering Work Information Management System (WIMS), CEMAS will use computer hardware acquired to support the Air Force Minicomputer Multiusers System (AMMUS). CEMAS will ultimately replace the multiple civil engineering support systems in use today and will improve materiel responsiveness. It will also help prevent fraud, waste, and abuse; provide total asset control and visibility; automate the bill-of-materials process; and automatically issue residue assets as requirements become known. Worldwide implementation/conversion will begin in FY86 and is scheduled to take three years to complete.

New Hardening/Chemical Protection Policy

Facility conventional hardening/chemical protection policy is being published in the USAF War and Mobilization Plan (WMP-1, Annex L). The policy expands upon previous guidance (and is compatible with existing USAFE/NATO criteria) to provide air base survivability protection policy for flight-line, logistics, and support facilities. It covers high and low conventional threat areas as well as considerations for terrorist threats. The new policy should provide a "roadmap" for developing balanced major command (MAJCOM) facility hardening/chemical protection programs to improve air base survivability, as well as a "yardstick" for Air Staff review/evaluation.

Synfuels Shale Oil Program

PROJECT RIVET SHALE, the USAF Synfuels Shale Oil Program, is expected to begin its operational validation phase during 1985. Mountain Home and Hill AFBs will exclusively use shale-derived JP-4 for a minimum of two years. In 1984, the Air Force Wright Aeronautical Laboratory completed an exhaustive research and development (R&D) effort using shale derived JP-4. As a result, "fly safe" certification for Air Force aircraft was issued. Union Oil of California, producer of the crude oil at Parachute Creek, Colorado, has experienced start-up delays but anticipates commencing full-scale production of 10,000 barrels per day later this year. The Air Force has long supported the development and routine use of jet fuels derived from alternate sources and is the lead service in support of DOD's number one energy priority—Supply Assurance.

A Manpower Impact Assessment Model for the Standard Base Supply System (SBSS)

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Background

Have you ever wondered why the Air Force implemented some new Standard Base Supply System (SBSS) policy that ended up causing three times more work? It was probably because a tool was not available at the decision level to show the manpower impact of policy changes. Now there is such a tool! The Air Force Logistics Management Center (AFLMC) has built the Manpower Impact Assessment Model which will forecast the impact of policy, procedural, or mission changes on SBSS manpower requirements. This model will also ultimately assess the impact such changes have on supply task execution and customer service. Further, it provides a more rational basis upon which policy or procedural decisions can be made—before the decision is made.

The Manpower Impact Assessment Model combines existing manpower standards with the experience, knowledge, and commonsense of supply personnel to provide reasonably accurate manpower projections by skill level at the unit, section, branch, and squadron levels. Also, the model provides the capability to extend these projections across a division, major command (MAJCOM), or even the entire Air Force.

The Model

Concept of Operation

The Manpower Impact Assessment Model is a FORTRAN-based computer model that applies the Air Force Manpower Standards for the SBSS to actual and projected workload factor data taken from the bases being modeled. This determines the present (baseline) and projected manpower authorizations. The model then compares the baseline to the projected manpower requirements to determine the net effect.

Input Requirements

An analysis of the manpower standards peculiar to the SBSS revealed there are 18 separate workload factors to measure for input into the model. All but one can easily be found in a Base Supply Management Report. The measurement of all these factors provides the first of the two data sets needed for input: the baseline workload factor data.

The second data set uses actual workload factors as a baseline to estimate changes resulting from mission, policy, or procedural changes. For example, at the AFLMC, a System to Analyze and Simulate Base Supply (SASBS) is available to project the change in the number of receipts and requisitions resulting from a stockage policy change. MAJCOMs can estimate the change in the workload factors resulting from a mission change by reviewing the data and M32 statistics at the

losing base. The proposed workload estimates do not have to be exact. Since the manpower standards react very slowly to changes in the workload factor values, estimates that are merely "in the ballpark" provide an accurate enough projection of manpower requirements.

Model Operation

The model operates by first applying actual workload factor data to the manpower standards to obtain actual manpower requirements. Then by repeating the process using the *projected* workload factor values, the model provides the predicted manpower requirements.

The standards are applied at the lowest organizational level which, in the SBSS, is the unit. The values obtained at this level are then consolidated at each successive management level to obtain the total effect on the SBSS. This approach enables individuals to identify the specific areas affected by the changes proposed.

Output

The model outputs actual and predicted manpower authorizations by skill level at the unit, section, branch, and squadron levels. These authorizations can then be projected across all bases supporting a particular weapon system, a MAJCOM, or the entire Air Force.

For instance, suppose a MAJCOM was considering a mission change that would result in a 20% increase in receipts and a 30% increase in issues. According to the model, the effect on the average SBSS in that MAJCOM would be:

CONUS Account Increase:

Air Force Specialty Code (AFSC)	Increase
6424	1
64551	1
64531	3

Overseas Account Increase:

Air Force Specialty Code (AFSC)	Increase
64599	1
64571	1
64551	5
64531	4

In addition to this output, the model would indicate the units, sections, and branches affected; the total effect on the command; and the personnel requirement increase or decrease by AFSC.

Validation

To ensure impartiality and add to the credibility of the model, the Air Force Maintenance, Supply, and Munitions Management Engineering Team (AFMSMMET) validated the model. Using a data set, AFMSMMET calculated the required manpower figures by hand. These were then compared to the model's output. Both produced identical results.

Assumptions and Limitations

The only assumption the model makes is the manpower standards are accurate estimates of the manpower needed to perform the mission of the SBSS. However, the model has several limitations. First, the Fuels and Administrative Branches of Base Supply are excluded from the model because the workload factors that determine their manning are not automated and would be difficult to obtain. Another limitation is the accuracy of the input determined by the user in estimating workload changes resulting from proposed mission, policy, or procedural changes. However, since manpower standards react very slowly to small changes in workload factor values, the user only needs to develop a *reasonable estimate* of the proposed workload to get an accurate answer. Finally, the model presently excludes units that are unique to a specific command or optional. These exclusions were done to make the model essentially generic and applicable to all commands.

Uses of the Model

The model provides objective measures of manpower impacts in terms of numbers and skills. It can be used to assess policy, mission, or procedural changes. For example:

(1) **Air Force Level:** The model can measure the manpower impact of the recent policy change which updated economic order quantity (EOQ) cost variables. Similarly, it can determine the effect of a procedural change, such as calculating the manpower required to accomplish the shift from batch item reconciliation to line item accounting in retail sales sections.

(2) **Major Command Level:** If a squadron of F-4s were to be shifted from Base A to Base B, the model could tell before the move began how many positions and what skill levels would be lost at Base A and gained at Base B. The model can also provide Supply planners a much more consistent, objective, and accurate method of determining manpower requirements for contingency operations.

(3) Base Level:

(a) If the Chief of Supply (COS) wanted to decentralize the demand processing unit (DPU), he could determine the exact number and skill levels of personnel needed in the decentralized DPU section.

(b) A Chief of Supply with a manning problem in Stock Control might consider increasing the local purchase order and shipping time (O&ST) in order to reduce the number of local purchase requisitions. The model can tell the COS how much to increase O&ST in order to bring workload in line with current manning.

Future Expansion

The development of this model does not signal the end of the AFLMC's efforts in this area; indeed, this is only the beginning. Ongoing and future projects will simplify data collection and add more objectivity to the process of estimating workload change. The key to both these efforts will be the identification of the driving workload factors; i.e., those factors that are at the heart of all SBSS operations and, consequently, determine the level for all other workload factors. Once the "drivers" are identified, AFLMC will quantify the relationship between these drivers and the remaining workload factors. This will reduce both the amount of actual data collection and the number of estimations.

In another future effort, AFLMC will attempt to relate the "driving" workload factors to some measure of the level of operations, such as flying hours or sortie rates. The relationship between supply workload and operational intensity, although intuitively obvious, is one that previous researchers have failed to document. Even so, the Center is confident a relationship exists. The discovery of this relationship will be of great benefit in evaluating the manpower impact of mission changes on the SBSS. This will be especially helpful when applying the model to supply contingency manpower planning where often the only reliable indicator of operational intensity is planned flying hours.

The impact assessment model comes with a user's guide and can be run on any Zenith 100 microcomputer. It is easy to operate and requires little microcomputer experience. The beauty of this model is in its simplicity. It is not only easy to use, but easy to understand, and gives management a valuable new planning tool.

Interested users can obtain a copy of the model through the Small Computer Applications for Logistics Engineering (SCALE) data base system. Instructions on how to access SCALE can be found in the SCALE User's Manual, AFLMC Report LY830801, which can be obtained by writing to AFLMC/LGY, Gunter AFS, Alabama 36114-6693.



"The more I see of war, the more I realize how it all depends on administration and transportation (logistics). . . . It takes little skill or imagination to see *where* you would like your army to be and *when*; it takes much knowledge and hard work to know where you can place your forces and whether you can maintain them there. A real knowledge of supply and movement factors must be the basis of every leader's plan; only then can he know how and when to take risks with those factors, and battles are won only by taking risks."

A.C.P. Wavell, *Speaking Generally*, 1946.



General O'Loughlin recently commented on five priorities to improve AFLC's contributions to US Air Force combat capabilities.

Return to Basics

General Earl T. O'Loughlin, USAF
Commander
Air Force Logistics Command
Wright-Patterson AFB, Ohio 45433-5000

In recent years, the Air Force Logistics Command (AFLC) has aggressively pursued numerous initiatives to upgrade its logistics processes and make them responsive to wartime needs. Many of these initiatives take advantage of new and emerging technologies which promise state-of-the-art improvements in the way logistics operations are conducted.

Our efforts have produced an Air Force-wide awareness that all elements of the logistics system must be integrated with the needs of the operational forces for effective results. To achieve this capability, we made several changes within AFLC, such as establishing the Logistics Operations Center and the Air Force Acquisition Logistics Center. These changes have noticeably improved Air Force readiness in general and logistics responsiveness under specific circumstances such as Grenada. We continually fine-tune the organization as we move forward.

Since I became commander in September 1984, we've had the opportunity to reflect on our progress so far. We are particularly proud of our people's achievements, especially those that have helped make logistics one of the keystones of Air Force decision-making. Now, we recognize we must consolidate our gains; future progress must not come at the expense of basic logistics support capability.

With all this in mind, I've established five equal priorities to stabilize the Command's operations even as we move toward full wartime capability. These programs ensure AFLC is recognized as an operational command in its own right.

Weapon System Support

Here we emphasize improvements to weapon readiness and sustainability, realistic war simulations, and optimum allocation of resources to the fighting wings. AFLC must stay in tune with customer needs, identify critical logistics elements, and reprogram available resources to ensure balanced support.

ADP System Modernization

AFLC is now pushing for modern, real-time computer systems. These include automation improvements essential to

better use of our resources, such as better visibility of assets, requirements accuracy, and effective stock control and distribution. We must develop logistics C³ systems that can respond to the demands of both peace and wartime.

Financial Management

We must do a better job of identifying fund requirements for specific program objectives. We need a flexible, near real-time capability to realign funds to changing mission needs, to make trade-off decisions wisely, and to enhance the credibility of our financial forecasts.

Quality of Life

The Command is striving to unlock the creative potential of AFLC's work force through better working conditions, performance incentives, and improved security measures. We are redressing a long-term decline which has undermined our efforts to attract the highly qualified and motivated people we need at all levels.

Image of the Command

AFLC fully intends to build a positive image with the media, Air Staff, Congress, the other major commands, other services, and allied countries. We want to emphasize our current capabilities rather than rationalize our limitations and shortcomings. When we keep moving forward, we improve our credibility and our success rate in the long run.

And that is what AFLC is up to, now and in the foreseeable future. I address these priorities at all levels within the Command, from the two-star Center commanders to our people on the lines. None of the five points is difficult to understand, but—on the other hand—none of them is easy to put into practice. We just have to get a little bit better every day.

Combined Air Warfare Course Invites Logisticians

The Combined Air Warfare Course at the USAF Air War College, Maxwell AFB, Alabama, offers valuable information and experience for logistics officers involved in the planning or conduct of theater air operations. The course objectives are: (1) to prepare officers to conduct/manage tactical air combat operations as members of theater air component and direct command support staffs above wing level, including the Tactical Air Control System (TACS) and joint/combined staffs; and (2) to enhance USAF readiness by fostering a "think war mind-set."

Over 500 staff positions in NATO headquarters, on the Air Staff, and at MAJCOMs and Separate Operating Agencies have been identified as having requirements for course attendance. They include operations, plans, logistics, intelligence, and other functional areas with duties in direct support of theater air combat operations. The curriculum emphasizes combined air-land force employment and includes coverage of NATO, Southwest Asia, and the Pacific region. The course has four curriculum areas: Area I, The Threat, provides an in-depth survey of the combat capabilities and military objectives of the Soviet Union, Warsaw Pact, and North Korea; Area II, Command Arrangements, discusses the organizations and force structures of theater commands; Area III, Capabilities and Employment, examines military forces and systems committed to combined and joint air-land warfare employment perspective; and Area IV, Theater War Exercise, provides a computer-assisted simulation whereby students develop plans and strategies to employ air power in a hypothetical war.

The course for active duty officers is four weeks in duration and is offered five times each year. Normal class size is 24-40 students per offering and quotas for course attendance are controlled by AWC/EDW. Three two-week sessions per year are offered to ARF officers, with quotas controlled by ANG/TE and HQ USAF/REP. The course is centrally funded. For further information, call Major Tony Stojak, AUTOVON 875-7831.

Depot Maintenance Spares Kit and the PRECOMP Model



Major John T. Boeck, USAF
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You are in the midst of what looks like a drawn-out conflict. Every sortie is critical. You are the Deputy Commander for Resources at a front-line wing. The base level self-sufficiency kit (BLSS) and other war reserve materiel (OWRM) are nearing depletion. The fourth aircraft is down because of a critical weapon delivery system part. The answer from the Air Force Logistics Command (AFLC) to your queries for support is that the source of repair (SOR) is "awaiting parts" for your critical unit.

What has gone wrong? You soon learn the major repair depots do not preposition war reserve materiel (WRM) to handle war repair surge. Therefore, the depot did not have enough component parts on hand to repair your critical unit. Given a 30-day order and ship time for the bits and pieces, a 15-day repair flow time, and a 7-day transportation time to your unit, you calculate you might get the critical unit in 52 days. Can you wait?

Unfortunately, this imaginary situation is too close to reality. To avoid it, AFLC is developing a method of refining computations and prepositioning components to be used to repair war-generated repairables. AFLC has always had the capability to compute OWRM levels and has had success in acquiring OWRM bits and pieces which are held at the source of supply (SOS). This "depot BLSS," called the Depot Maintenance Spares Kit (DMSK), and the Prepositioning Components (PRECOMP) model that does the actual bit and piece computations, will provide special SOR levels for every essential repairable item.

War-Fighting Concepts Drive Support Concepts

During the formative years of WRM concepts, defense guidance drove the major commands (MAJCOMs) to prepare for conflicts of short duration. This and fiscal concerns led to concentration on building up logistics support required to fight short, intense conflicts from a self-sufficiency perspective. In such conditions, repair depots would not play extensively in war because they could not respond in time frames that would make a difference. Therefore, these depots did not preposition war surge repair components. But we now anticipate longer war scenarios. These scenarios call for SORs to be "brought to the front" in concept (by use of improved theater-CONUS airlift and depot repair flexibility) so they can obtain repairable carcasses and provide valuable spares in time frames necessary to supplement BLSS and war readiness spares kits (WRSKs). Then, as "field" spares run out, the SOR would fill the pipeline to prevent deficits.

This concept requires a great deal of flexibility in the SOR—a more "reactive" support instead of the normal

programmed workloading. This, in turn, requires an ability to prioritize and move from one critical item to another without confronting problems like AWP (awaiting parts) status. To meet this new concept, the SOR is going to take an "up front" responsibility for quickly supplying parts to the flying units. To do this, they—just like the flying units—need a stock of parts on hand.

Factors That Affect Supportability

SORs have sufficient equipment and skills to repair assigned end items. They exercise "surge" activities in which they spread out manpower to cover losses due to general mobilization. However, given overhires and overtime, they can operate 24 hours a day, 7 days a week. Given high quantities of items requiring a particular piece of repair equipment, they can meet demands by using queuing techniques. With good workload priorities, aircraft system repair can keep moving. In an exercise called WINTEX-CIMEX 85, Ogden Air Logistics Center (OO-ALC) showed all repairables on-station could be repaired in less than 40 days *given parts availability*. The lack of component parts was the prime culprit in failure to provide serviceable end items for mission aircraft.

Traditionally, SORs stock the minimum quantity of components sufficient to complete their peacetime repairs. Additionally, item managers at that depot, who handle part support for worldwide demands, maintain a stock of the parts for which they are responsible. But, of the five major SORs, none presently have anything comparable to an operational base's BLSS or WRM.

Gathering the components necessary for repair takes varying lead times. To ensure the SOSs (Defense Logistics Agency (DLA), contractors, etc.) have adequate quantities on hand for SOR maintenance to order, requirements estimates are computed by automated systems. These estimates, made almost two years before the components are placed in SOR supply, provide the lead time to obtain parts from manufacturers and allow the Air Force to conserve funds by ordering in lot sizes for which that manufacturer will give price breaks. Requirements computations are based on many factors, but historical demand data on each repairable item primarily drives the estimates. If the demand behavior of an item deviates from the historical behavior, related shortages (or sometimes an excess) of repair parts can quickly result.

To minimize inventory holding costs, the supply management system moves component parts to the SOR as needed and only in quantities estimated to be used in the short term. This means SORs stock only for peacetime repair

requirements. Other stock estimated in requirements computations is kept at the SOS until needed. If an unprogrammed demand hits the SOR above the expected level, the system will not have stocked needed parts and will fall short of the repair requirement. This occurs in peacetime, but is much more likely in war since wartime demand rates exceed peacetime rates due to increases in flying hours and sorties. Further, end item demand behavior may differ because of changes in end item use. These factors, coupled with the ambient level of uncertainty in the historical data base, create a large potential for nonsupport in wartime. In peacetime we can live with fewer training sorties but, in war or contingency, fewer sorties could cost dearly.

First Step Towards DMSK Computation

The purpose of the DMSK would be to overcome parts shortages due to surge or war repair demand. DMSK would preposition components at SORs for wartime repair of end items. The PRECOMP model has a specially prepared input to compute these levels and drive requirements to the supply system for specific kit items.

The DMSK is set up by first running the LOGRAM model at HQ AFLC. This model generates a war repair requirement for essential end items in the form of a national stock number (NSN) and quantity per given time frame (Figure 1). Presently, a 60-day requirement (D-Day+31 to 90) is used for DMSK computations. The computations are based on historical usage of an item and related mean time between failure (MTBF). The computation applies the MTBF to the war flying hours scenario. The incremental change between peacetime and wartime flying hour programs is applied to create the same incremental change in repair demands. In this way, the system arrives at an estimate of the scenario's repair demands. (The scenario is based on HQ AFLC analysis and is the "worst-case" scenario as outlined by HQ USAF/XOX.)

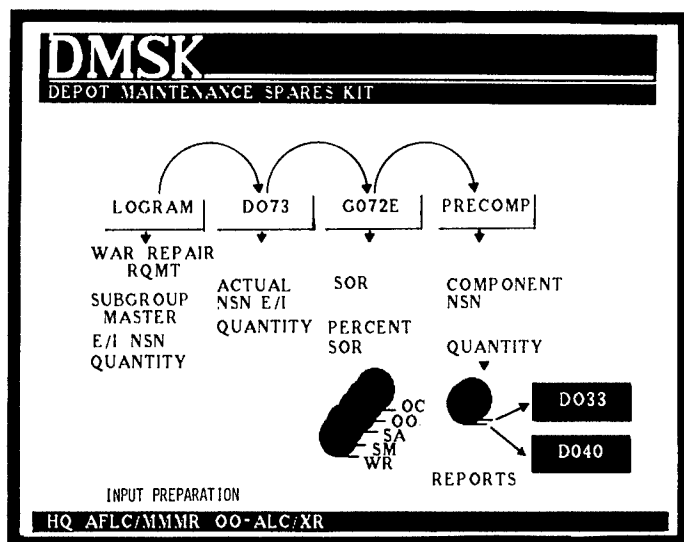


Figure 1.

The war repair requirement must be converted from subgroup masters to "actual NSNs." The subgroup master is one NSN that is the master for a group of like end items. The repairable generation percent of each actual end item must be applied to the master's repair requirement. This provides a

quantity for each actual item needing repair. This allows identification, by item, of the SORs and components required. The LOGRAM output is run in a special program using the D073 management of items subject to repair (MISTR) requirements computation data base to make the conversion.

Next, the actual repair requirement is identified by SOR. Some items are repaired at more than one SOR, so the total requirement for an item must be proportionally split and identified accordingly. This ensures correct distribution of total repair component parts. The G072E depot maintenance long-range program is used to prepare this final portion of the input to PRECOMP.

All actual end items requiring repair and their respective quantities are then sorted by SOR and five tapes are created—one for each major SOR. These tapes provide the inputs to PRECOMP. The model will use the NSNs and repair quantities to compute total component needs. It will then produce both reports and tape drives to create the DMSK levels in SOR supply systems.

PRECOMP Model

The PRECOMP model is a deterministic computational tool. The model produces a visibility of component requirements across all aircraft included in each scenario. Presently, the model is run on a Digital VAX 11-780.

The DMSK system consists of two steps: input formation and computation. *Input formation* is a series of adjustments to the LOGRAM's repair requirement output and is produced by AFLC/MMMR. This input is sent to the processing ALC to run on PRECOMP. There, data bases unique to ALCs and their repair workloads are most easily accessed. Inputs to PRECOMP are expected to be accomplished by automated feed; it is possible to edit the entire data base to do either small selective computations or sensitivity analysis. In fact, the model can be used to test the effects of changes in war repair computations with no impact on major systems since it is an independent data processor. By deleting the programs that produce drive tapes and using the edit feature or a tailored tape input, experimentation is possible to derive DMSK management decisions.

PRECOMP uses the MISTR material standard (G005M) system to break each end item down to its replaceable components. The G005M has a bill of materials (BOM) for each repaired item. The BOM identifies the parts required, the quantities of parts per assembly (QPA), and how often each component is replaced (RPL PCT) when the end item goes through repair. The model links all components with their respective end item and related repair specifications to create a unique data base. Constructing this separate base precludes multiple accesses of a giant G005M data base, thereby allowing faster modeling time. The model then selects each component NSN and searches for a match. By combining all matched components, the total component requirement for all end items is derived.

The BOM can contain both nonrepairable components (resistors, brackets) and repairable subassemblies called shop repairable units (SRUs). SRUs (power supplies, actuators) can also have BOMs, but these are not included in higher assembly BOMs. Rather, they are treated as complete serviceable units in DMSK. This is because the shops require the SRUs as serviceable units and "shop-route" unserviceables to other shops for repair. Therefore, the model does not compute additional economical order quantity (EOQ) items for all

SRUs in a higher assembly. Components to repair the SRUs require a computation of SRU war repair requirements just as with an LRU (Figure 2).

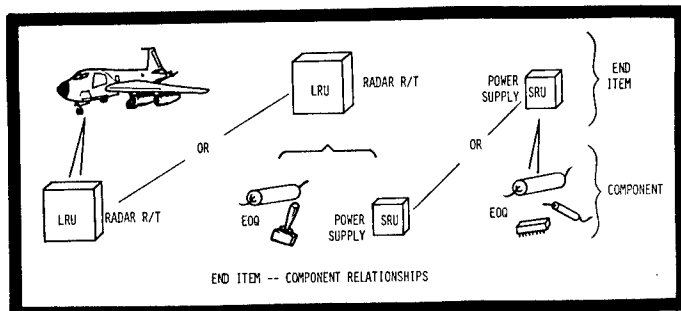


Figure 2.

Since there is already a level of many of the required components in stock at the depots, this must be accounted for in computing the DMSK level. After PRECOMP has computed the total component requirement for the total war repair requirement for each SOR, peacetime operating stock (POS) assets must be subtracted. These are represented by the "reorder level" of each component from the Depot Supply System, D033. It is not practical to use "snapshots" of what is available, since this fluctuates hourly and daily as maintenance uses the components. But these actual quantities pivot around the *reorder level*, which is the only steady criteria associated with component quantity levels. The reorder level is subtracted from the total component requirement (TCR). The result is delta (Δ) or the DMSK level.

The model uses the cost per component to estimate total component costs related to DMSK. Detailed reports are available showing the process as well as other information pertinent to analysts and decision makers.

PRECOMP can select and sort by the type of component. Also, small bits and pieces can be separated from repairable components. This is important for financial management because, although repairable components are generally expensive, consumables are often just the opposite. By selectively reviewing the different types of components and related costs, managers can improve kit composition decisions.

Outputs

There are two types of reports for three categories of DMSK items. PRECOMP produces the detail report for each computation mentioned and a summation of costs across each category of items (Figures 3 and 4). The categories consist of SRUs (components that are repairable) and two subgroups of EQQ: service support division (SSD) and general support division (GSD). SSD items are those managed by a branch of the military—mostly Air Force in our case. An SSD item has an item manager stationed in the Materiel Management Division at one of the five major depots. The item manager has prime responsibility for ensuring availability of assigned components. Item managers interact with manufacturers to requisition parts and make them available in SOR supply. GSD items are managed by the DLA or another wholesale supplier. Supply divisions at each SOR are responsible for requisitioning GSD items from these SOSs.

To make analysis and ordering actions easier, PRECOMP sorts information differently to produce reports tailored to the different recipients. Information on recoverable (SRU) and SSD items, both of which are handled by service item

DMSK										
DEPOT MAINTENANCE				SPARES KIT						
DMSK DETAIL						PRIME: OO-ALC				
SSD						DATE: 100485				
MM IMS: DHT										
COMPONENT NSN				UI: WS		ERRC: N		MDS: F016A, F016B		
15600011139485WF										
NUT BOLS ASSY										
END ITEM NSN		SOR RQ		E/I SCHED PCN		PDN RPL PCT		BASIC SAFETY COMP/ QPA RQMT LEVEL		E/I
1280011640397WF OC		80		54328C ATLMMT		54329A 100 01		80 09		89
1280011647397WF 00		00		23459S BNGFRR		98475A 100 02		00 00		00
1280011649297WF OC		05		32165D GFDREP		76810A 100 10		50 08		<u>58</u>
TOTAL COST				UNIT COST		TOTAL COMP RQMT				147
2000.00				100.00		REORDER LEVEL				<u>127</u>
						DELTA				20
HQ AFLO/MMMR OO-ALC/XR										

Figure 3.

DMSK		
DEPOT	MAINTENANCE	SPARES KIT
DMSK RECOVERABLE BUDGET PROFILE		DATE: 100485
PRIME ALC: OC-ALC		
MM IMS: LMM		
COMPONENT COSTS:		
WITHOUT HIGH EXPENSE: 2,780,000.00		WITH: 3,980,000.00
HIGH EXPENSE DETAIL (OVER 500K)		
165001830398WF	580,000.00	
5841011493220WF	620,000.00	
HQ AFLO/MMMR OO-ALC/XR		

Figure 4.

managers, are consolidated after all the SOR runs are complete. They are then sorted by SOS (the "prime manager" depot) and by individual item managers. GSD reports are sorted by SOR.

The detail report is printed from the *component* perspective. All end items that use the subject component in repair actions are listed below the component. Information related to components used in the end item in that row is arrayed across the page. The computation to derive the required components per end item ("COMP/EI") is:

$$EI RQMT \times QPA \times RPL PCT = BASIC RQMT$$

As in WRM computations, a safety level is added:

$$BASIC RQMT + \sqrt{BASIC RQMT} = COMP/EI$$

All COMP/EI are totaled for the TOTAL COMPONENT REQUIREMENT (TCR).

$$TCR - REORDER LVL (POS offset) = \Delta \text{ or DMSK LEVEL}$$

$$\Delta \times COST/UNIT = TOTAL COST \text{ for the subject component}$$

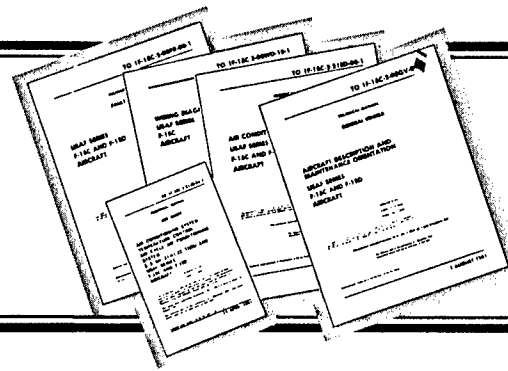
Technical Order Acquisition Cycle

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Introduction

People often complain that technical orders (TOs) are too expensive, poorly written, and never delivered on time. The tragedy of this statement is it is true. What they often fail to recognize, though, is that TOs are a by-product of the acquisition process. The TOs delivered to the user in the field are the direct result of decisions made by a systems project office (SPO)/project manager (PM) months or even years prior to delivery. The irony of this situation is the Air Force acquisition process for weapon systems is designed to identify and correct problems that would preclude the delivery of poor quality products to the user. If so, then why does this still occur time and time again? Because—the process is very complex, progressing through different phases of development and requiring close coordination and cooperation by various organizations. Cutbacks in funding, ill-advised program trade-offs, lack of understanding of TO impact on life cycle cost, and lack of proper task identification to the contractor(s) all influence the quality and timeliness of TOs.

If properly followed, the acquisition process allows for adequate planning during the preconcept and concept exploration phases; proper task identification and documentation during the validation phase; timely contractor guidance and TO validation during full-scale development; and proper verification, inspection, and acceptance during the production phase. Unfortunately, calculated decisions made by managers at all levels to meet production schedules or correct short-term crisis conditions introduce problems that become more costly and difficult to correct at each subsequent phase of weapon system development. Circumvention at any phase during the planning and development of TOs will ripple through all phases of the system and have the whiplash effect of a five megaton nuclear explosion when the TOs are delivered to the user. This article identifies the major management functions that must be addressed during the acquisition of TOs. It is not intended as a cure-all for all acquisition programs because the process is too complex for a checklist solution. However, the article does highlight important functions that will enhance the supportability and maintainability of a weapon system.

Pre-Concept Phase

Early planning and coordination of total system requirements are critical to maintaining the operational readiness of our Armed Forces and can mean a savings of millions of dollars during the life cycle of a weapon system. The Department of Defense (DOD) has long recognized the need for total system development and recently reinforced this concept by identifying logistics supportability as a design requirement equally as important as cost, schedule, and

performance. TO development is a key element of the total system.

Early planning for TOs should begin with the using command in the preparation of the statement of need (SON). Planting the initial seed for TO acquisition during the preconcept phase will allow managers at all levels to consider TOs concurrently with the total program planning effort and ensure they are compatible with the overall program objectives. Defining specific details is not the objective during the preconcept phase, but the management team must understand the TO implications and have the ability to apply this understanding while the concept is being formulated.

Concept Exploration Phase

This phase begins with favorable consideration of the user's needs and a DOD decision to consider alternatives to meet those needs. Various program alternatives are being generated and examined with little or no hardware involved. The major products of this phase are data which, in the form of studies, analyses, and test results, demonstrate that certain concepts exist which might satisfy the need. An important consideration at this point is the evaluation of state-of-the-art technology that will enhance the development of TOs. Viable alternatives that will increase operational readiness and reduce life cycle cost will be more readily accepted *now* than later in the acquisition cycle. Influencing the TO acquisition process becomes more difficult as engineering design and acquisition strategy are solidified. The key to developing quality TOs at competitive cost is to address these requirements during concept formulation. Some factors to consider are:

- (1) Applying current technical data methods and programs.
- (2) Applying and accepting new technical data concepts and media.
- (3) Finding and accepting commercial data.
- (4) Improving management concepts and techniques that will allow for cost tracking.
- (5) Establishing effective coordination procedures during technical publications development.
- (6) Incorporating a good quality assurance program during development.
- (7) Establishing overall engineering data structuring and flow process.

Demonstration and Validation Phase

This is a very important phase in the acquisition process in terms of providing the necessary interface between the system design, user, and logistics community. This is when the cadre in the system program office will be expanded and organized to manage the identification and coordination of contractor

tasking requirements through the preparation of the statement of work (SOW), contract data requirements list (CDRL), and supporting military specifications and data item descriptions.

The system management philosophy is to designate a single manager to be responsible for the total development and acquisition of a weapon system. The program manager is responsible for managing the total resources for the acquisition of Air Force equipment. This management task is so complex that the program manager must establish an organization of personnel with expertise in many functional areas, such as engineering, contracting, configuration management, provisioning, and data management. A key member of this management team is the TO manager.

The TO manager is the linchpin of the Technical Order Management Agency (TOMA). The TOMA is the program office that has overall management responsibility for the acquisition of TOs needed to install, operate, maintain, inspect, overhaul, and modify the system and equipment procured. The TO manager will initiate planning for TOs so they are developed concurrently with the total program planning effort and are compatible with the maintenance plan and overall program objectives.

During the early planning stages, emphasis should be placed on the TO manager's learning the requirements of the program and establishing points of contact with the using command, Air Force Logistics Command (AFLC), Air Force Acquisition Logistics Center (AFALC), Air Training Command (ATC), and other applicable Air Force organizations. Early contact with these organizations enables the TO manager to disseminate program guidance and discuss planning for the development of TOs. For example, is this weapon system going to be a stand-alone system or will it require support equipment? What is the maintenance concept? Has guidance been given on an initial operational capability (IOC) or any other established time schedule? The TO manager must initiate coordination and dialogue with counterparts on these and other issues if TOs are to be available on a timely basis to operate and maintain Air Force equipment.

Early discussion of requirements with counterparts allows the using and supporting commands the opportunity to plan personnel and funding for program support. The TO manager must not only initiate contact and coordination with Air Force organizations outside the program office but also be an active participant in coordinating requirements with the other functional elements within the program office. The TO manager coordinates with the data management office (DMO) on data requirements and distribution of the initial data call. ATC and operating and supporting activities are recipients and active participants of this initial data call. Of course, the prime air logistics center also plays an active role during all system acquisitions in preparing data requirements to support TOs. The TO manager must carefully orchestrate this effort and be a tactful negotiator in resolving differences between program office constraints and technical data requirements identified by ATC and operating and supporting activities.

During the validation phase, the TO manager builds the framework of the TO system that will support a new weapon. Conceptual planning begins to solidify into firm requirements as selection of a contractor approaches. A key function of the TOMA is to prepare and coordinate TO requirements for the draft SOW. And, since development testing of the new weapon system cannot be done without technical guidance, it is important for the TOMA to determine TO distribution

requirements for the early training and test functions. At the same time, responses to the initial data call require the TOMA to review and resolve TO conflicts based on these inputs and data call/requirements conferences. These actions allow the TOMA to clearly specify TO requirements in the final SOW and participate in the contractor selection process. Once this is done, an effective program office/contractor relationship can be built as the TOMA hosts the first of a series of TO guidance conferences.

These tasks must be accomplished within the framework and guidelines established by the program manager. Timely coordination and tactful negotiations are instrumental in successful completion of the TO manager's job. Prompt identification of these requirements during the competitive phase of negotiations highlights to contractors the work effort required and establishes a solid foundation on which to build a quality product. The SOW, of course, communicates program office needs to the contractor in a legal binding agreement. Data items to be evaluated and considered as tasks in the SOW include:

(1) **Technical order plan (DI-M-3401 or DI-M-6145).** Prepared by the contractor, this data item (DI) prescribes the general procedures and conditions governing the planning, preparation, selection, and delivery of technical publications required for maintenance, operational, and training support of systems/equipment being procured.

(2) **Technical order status and schedules (DI-M-3402 or DI-M-6155).** Through these items, the contractor provides status information on preparation and delivery of technical publications in accordance with approved schedules.

(3) **Explosive ordnance disposal procedures (DI-M-3403).** This DI identifies technical data required for the preparation of nonnuclear ordnance and aircraft explosive ordnance disposal (EOD) procedure TOs in the Air Force 60-series TOs.

(4) **Technical order contractor-furnished equipment (CFE) (DI-M-3405 or DI-M-6156).** This provides the contractor a vehicle to submit recommendations on technical publications required to support hardware and acquired from vendors.

(5) **Technical order/commercial literature (DI-M-3407 or DI-M-6153).** This item prescribes to the contractor the source documentation to be used for the preparation of technical publications.

(6) **Validation record, technical orders (DI-M-3408 or DI-M-6159).** Prepared by the contractor, this record identifies times and dates when all operating and maintenance procedures are tested or validated by actual performance or as otherwise specified by the program office.

(7) **Report of technical manual cost (DI-F-6126).** This financial report provides the vehicle whereby the program office may obtain from the contractor(s) the cost for technical publications being developed under the terms of the contract.

The proper identification of the tasks and support documentation, e.g., military specifications, data item description, military standards, and Air Force acquisition documents, provides a contractor with the initial guidance on the work effort and resources required to accomplish the job. Every TO manager *must* tailor all support documentation identified in the SOW or contract data requirements list (CDRL) to specific requirements of that program. *Program cost drivers* inevitably result when this important process is not diligently accomplished.

Full-Scale Development

During this phase, the contractors convert design concepts to firm, detailed designs and perform the test and evaluation of prototype system hardware. As the system/equipment design becomes increasingly firm, formal procedural data requirements are established. Also, the contractors prepare draft manuscripts to be used during their validation of manuals. A key consideration is the incorporation of quality assurance procedures into the development of TOs. While both the government and the contractor work jointly to implement an effective quality assurance program, the contractor has prime responsibility for incorporating quality assurance into the development of TOs. The quality assurance plan should include: (1) instructions providing details on administration of a quality assurance program, such as inspection procedures, record keeping, and actions to correct discrepancies; (2) a validation plan detailing availability of qualified personnel, showing a time schedule plan, and establishing priorities on availability of equipment; and (3) the contractors' responsibility for supporting the Air Force verification effort, including availability of facilities, availability of proper documentation and data, and availability of qualified personnel.

The contractor must ensure all technical publications/data prepared for the Air Force are in accordance with contract data requirements or military specifications. Technical publications prepared by the contractor must be subject to inspection, verification, and approval/disapproval by the Air Force as specified by the contract.

Some of the major concerns for the TO manager and contractor during full-scale development are shown in Table 1.

Contractor:

Initiates development of TOs in accordance with contract requirements.

- Reviews commercial manuals for applicability or possible revision to comply with government requirements.
- Initiates TO validation.
- Formalizes technical order publication plan (TOPP) according to government guidance.

Technical Order Manager:

Coordinates specific quality assurance responsibilities with appropriate activities.

- Coordinates TO number assignment.
- Arranges for early delivery of preliminary TOs to training command and Air Force test and verification teams.
- Arranges for effective accounting and distribution of preliminary TOs used for verification.
- Arranges for printing TOs through the Government Printing Office.
- Establishes a TO verification plan to be implemented upon production go-ahead.

Table 1.

Production Phase

If, as a result of the testing and evaluation of the hardware systems during full-scale development, the Air Force decides to go into production, the contractor incorporates the latest design changes and begins the process of manufacturing and assembling the system. During this time, the TO manager

coordinates with the contractor to initiate the military verification effort for TOs prepared by the contractor. *Verification* is accomplished on manuals after they have been *validated* by the contractor. Military test and verification activities (which include the user) test the manuals to ensure they are clear and adequate for the operation and maintenance of associated equipment and for certifying that the manuals are compatible with the pertinent hardware, tools, and support equipment. Verification is not normally started until after the engineering design has stabilized and the production decision has been made. Verification consists of the actual performance of procedures by using command and testing personnel in the operational environment. As the publications are verified, the TO manager arranges for printing and general distribution according to plan. As soon as the various quality assurance actions are accomplished, the manuals can be delivered. Validation and verification are critical functions, because they are the impetus for incorporating quality assurance into the development process. They are also the most difficult tasks for the TO manager to coordinate. The process cannot be curtailed or waived without impacting the ultimate quality and cost of technical publications. If properly done, the relatively small acquisition costs of quality TOs pay huge dividends in lowered life cycle costs.

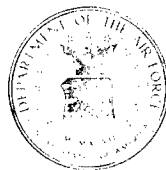
Unfortunately, the smooth transition of this process historically has been hampered by ill-advised trade-offs and program reductions that have impacted unfavorably on operational readiness and support. Managers at all levels must understand that each time quality assurance steps are waived, this relieves the contractor of satisfying the contract requirements. This translates to spending more money to correct errors in the manuals because time was not taken to do the job right the first time.

Other areas of responsibility for the TO manager during the production phase include continuing in-process and prepublication reviews, formally inspecting and accepting deliveries, publishing and distributing manuals, hosting post-publication reviews, and coordinating with AFLC for eventual program management responsibility transfer (PMRT).

Summary

The responsibility for managing the acquisition and development of thousands of TOs in various stages of development for a major weapon system is a gigantic and critical task that demands management attention at all levels. Clearly, the complexity of the process requires a total team effort from the program office, user, logistics command, training command, and contractor. The most important key to timely and accurate development of TOs is early planning and coordination. To achieve this, the TO manager must initiate early dialogue and orchestrate this dialogue between the program office and other command organizations. But today's weapon systems are too complex for any one person or office to possess the expertise required to effectively manage the total acquisition process. The TO manager must therefore coordinate and seek the assistance of other organizations. While the TOs are prepared by a contractor/manufacturer, they are prepared in accordance with guidance and instructions coordinated by the program office. Timely development and coordination of these requirements can ensure the Air Force receives accurate and cost-effective technical orders that truly meet the needs of the user.





CAREER AND PERSONNEL INFORMATION

Civilian Career Management

MIS and LCCEP: A Winning Combination

A Management Information System (MIS), currently in design, will provide senior logisticians with a valuable tool for developing a well-rounded logistics work force. The system will reveal the areas where training or developmental assignments are required or have been accomplished, which will in turn ensure highly qualified personnel are more readily identified for projected vacancies.

Although this new system will service all career programs managed by the Office of Civilian Personnel Operations (OCPO), the Logistics Civilian Career Enhancement Program (LCCEP) was selected to be the leader in development, since it is the first and largest computer-based career program for civilians. Three logisticians with systems experience have been developing the project since January 1985 and are guided by a task group representing each of the other eight career programs.

The MIS will support all career program policy councils and their panels. These councils are composed of senior representatives from their functional communities and senior civilian personnel officers. The LCCEP Policy Council is co-chaired by Lieutenant General Leo Marquez, Deputy Chief of Staff, Logistics and Engineering, and Mr Lloyd K. Mosemann II, Deputy Assistant Secretary of the Air Force (Logistics and Communications). Logisticians will see improvements in processing fill actions for centrally-managed positions; developing

and testing promotion evaluation patterns; identifying and managing program registrants and high potential civilians; and managing training, intern, and career development programs. However, a myriad of information is needed to develop and administer these policies and evaluate their results. The insufficient quantity and quality of today's available data limits the LCCEP's effectiveness; however, OCPO is using a modular development approach to quickly respond to information requirements. Full implementation is to be completed by December 1987.

Nearly all logisticians involved with career programs will benefit from the MIS. The Policy Council and panels will use statistical techniques and information arraying capabilities to formulate and evaluate career program policies. OCPO career program personnel will use the system to support their operational taskings. Senior logisticians and managers at the major command (MAJCOM), HQ USAF, and other functional areas will use the system for projecting attrition, determining training requirements for high potential candidates, and tracking affirmative action progress. They will also use the MIS to assist in counseling employees on promotion requirements and shortfalls in skills or training needs.

Modern technology, coupled with dedicated logisticians, is the key to providing better methods for managing the LCCEP. The MIS should result in a higher quality, better motivated work force to meet Air Force mission needs.

Source: Ray Twardowski, OCPO/MPKCL.

(The Military Career Management portion will resume in the Fall issue.)

LOGCAS '85 Announced

The HQ USAF Directorate of Logistics Plans and Programs (HQ USAF/LEX) announces the Fifth Annual Logistics Capability Assessment Symposium (LOGCAS) which will be held at the United States Air Force Academy, Colorado, 7-11 October 1985. The purpose of the symposium is to provide an unclassified forum of presentation for Air Force analysts and managers involved in logistics capability assessment.

The theme of this year's symposium is "Information Synthesis for the Decision Process: A Continuing Challenge." Over the last decade, the Air Force has made great progress in developing new tools and techniques. At this year's symposium, we will look at new developments:

Consistency
Communications

Coalescence

- Agreed Measures of Merit
- Retrieval of Information and Interface with Developing and Existing Systems and Models
- Convergence of Day-to-Day Processes with New Analytical Methods and Information Technology

We are including tutorial sessions on microcomputer applications and invite your participation and presentation.

If you wish to attend LOGCAS '85 or submit a paper for presentation, contact Captain Mike Cox or Capt Craig Carter, AFLMC/LGY, Gunter AFS AL 36114-6693, AUTOVON 446-3514, Commercial (205) 279-3514.

Initiative: Improve System Support Readiness How Serious Are We About Logistics?

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Introduction

Much has been written about logistics supportability and operational readiness in the last few years. With the publication of Department of Defense Directive (DODD) 5000.39, *Acquisition and Management of Integrated Logistics Support for Systems and Equipment* (January 1980), and the Carlucci Initiatives (April 1981), and now the Acquisition Improvement Program, the logistics management function may finally have its day in the sun. Even the new DODD 5000.1, *Major System Acquisition* (29 Mar 82), stated: "Improved readiness and sustainability are primary objectives of the acquisition process" and "logistics supportability shall be considered early in the formulation of the acquisition strategy and in its implementation."

After the issuance of DODD 5000.39, all the services began to update their old regulations or create new ones on integrated logistics support (ILS). At the same time, a rising tide of ILS language began appearing in the logistics section of Department of Defense (DOD) requests for proposal (RFP). What used to take two or three paragraphs to explain now took several pages—each program office had an idea how it should be done.

Eventually, the rush of new ILS language settled down, and ILS handbooks and some standardization in requirements surfaced. Standardization on logistics related analytical tasks became reality and very little, if anything, changed in regard to the minimum acceptable level of ILS functional management and management integration. This author's view is based upon having reviewed, over the last four years, most of the RFPs on major weapon system acquisitions which required Air Force contract administration.

This is where we are today—much tasking without any standard requirements on contracts regarding the management aspect of ILS. Consider the plight of defense contractors and their respective government contract administrators when several major weapon system contracts are in their facility and each contract requires a different management structure or philosophy. The real cost to the government is staggering and unnecessary.

How Quality Assurance Does It

In Quality Assurance, the track through the "thou shall" document is an easy one. DODD 4155.1, *Quality Program*, states:

The Under Secretary of Defense for Research and Engineering (USDR&E), or a designee shall:

a. Develop, plan, coordinate and provide policy direction and guidance for DOD quality programs.

b. Assure that acquisition related quality policies stated in this Directive are implemented in the Defense Acquisition Regulation established by DOD Directive 5000.35. . . .

The policy continues to levy similar responsibilities on the Assistant Secretary of Defense (Manpower, Installations and Logistics) (ASD (MI&L)) down to the DOD components. At the DOD level lies the requirement to "develop and use joint procedures for uniform implementation of quality programs." Keep in mind that DODDs are not contractual tasking documents. In order for a DODD to be implemented on a contract, specific tasks must be placed in the statement of work (SOW) section of the RFP. If the manager does not want everyone creating new implementation language for each contract, he must write a military standard (MIL-STD) or military specification (MIL-SPEC) in order to standardize requirements, and then place the MIL-STD/SPEC on contract. This procedure assures continuity from policy to implementation.

MIL-Q-9858A, *Quality Program Requirements*, is a powerful MIL-SPEC which:

a. Requires the establishment of a quality program by the contractor which is to be fully documented and subject to the disapproval of the government.

b. Assures adequate quality throughout all areas of contract performance.

c. Provides for the contractor to clearly prescribe effective management for quality.

d. Provides that personnel performing quality functions shall have sufficient, well-defined responsibility, authority, and the organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions.

Thus, in the area of quality assurance, complete trackability and continuity for the function are provided—policy, guidance, direction, means of contract implementation, and contractor management requirements.

Production Management Track

DODD 4245.6, *Defense Production Management*, assigns the responsibility of timely assessment of production risks, production feasibility, production capability, and readiness to each DOD component. This assessment of contractor production management places continued emphasis on life cycle cost reduction during the production phase. The directive further states:

a. Production management planning and implementation shall include provisions for measuring progress in meeting design-to-cost and life cycle cost commitments.

b. Production management shall be specifically addressed at each program milestone decision point in the major system acquisition process subsequent to Program Initiation.

Because of the importance and the attention given to production management assessments, the need for a MIL-STD was evident, so MIL-STD-1528 (USAF), *Production Management*, was established.

Up to this point, similar to quality assurance management and ILS management, a proliferation of contract language existed which told contractors what the Air Force wanted in the way of production management systems. The Air Force saw a need for a standard requirement which assured the establishment of an effective production management system—one which was planned, documented, and implemented in consonance with related technical and management disciplines. In other words, the goal was an integrated system where production risks and capability assessments could be viewed from a holistic perspective instead of from isolated viewpoints.

MIL-STD-1528 requires that:

a. The production management implement the requirements and the contract of this standard.

b. The contractor establish and use an internal review process to monitor production management system effectiveness.

c. The contractor establish an internal effective interface and working relationship among design, development, and production engineers; production planners; overall program planning and control personnel; and specialists in development engineering configuration management, less program management safety, integrated logistics support, facilities, and quality assurance. When a contractor is required to establish an "effective interface and working relationship," contract administrators must determine the criteria which tells if the contractor is in compliance with the MIL-STD.

It is obvious we need a requirement for a totally integrated systems (holistic) management approach of production management and once again for a functional discipline, with complete trackability and continuity provided.

A similar continuity track can be shown for configuration management, engineering management, system safety management, and test and evaluation management. This continuity is the precise thing necessary for ILS to work, but it is not formally required.

Integrated Logistics Support Management Today

As stated in the introduction, there is a track for ILS management from DODD 5000.1, to DODD 5000.39, to DOD

component regulations. But that is basically as far as it goes.

Many would agree MIL-STD-1388-1A gives management direction and guidance. However, I believe that it only gives such direction and guidance specifically to the conduct of analysis.

Today, we in the acquisition logistics business are tasking our contractors through the SOW in contracts. The ILS process itself fails in not giving a requirement for minimum acceptable ILS management practices. We are, therefore, not providing the foundation for lasting and effective ILS management. Good ILS management must be effective for the entire life cycle of a system to include post-production support.

On the other hand, DODD 5000.1 requires a balance be struck between cost, schedule, performance, and supportability. In each area, except supportability, a framework exists for management integration and control. Within each is a management framework to determine the functional management adequacy and performance relative to a specific discipline. This is not the case with ILS. Each OPR must attempt to reinvent the wheel of "ILS management" with each request for proposal.

If We Were Serious About Logistics

I believe a MIL-STD or a MIL-SPEC incorporating similar requirements as other functional management MIL-STDs/MIL-SPECs would assure the contractors provide a better system approach on ILS. Today, there is no guarantee that a task assigned by MIL-STD-1388-1A could be resolved in a fully multi-disciplined systems integrated approach. One person could do the analysis "in a vacuum" and be in compliance with the contract.

Once such a MIL-STD/SPEC was placed on contract, the Contract Administration Services (CAS) or the Program Office would have to assure contract compliance. Compliance criteria would be established and the contractor's ILS management health could be ascertained on a systematic basis.

Operation readiness and sustainability are primarily a function of logistics supportability. The continuity that a MIL-STD or MIL-SPEC in ILS management provides would effect better trade-off analyses. The better trade-offs and day-to-day attention by management to the integrative, multi-functional nature of ILS will, in turn, build enhanced operational readiness and supportability.

ALP

UPDATE: Core Automated Maintenance System (CAMS)

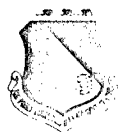
CAMS Increment 1 entered field testing at Dyess AFB 19 February 1985, on schedule, after quality assurance testing was completed without significant problems. Each MAJCOM will be receiving a test system within the next few months. The formal decision to employ CAMS Air Force wide is scheduled for April 1986. The remaining six increments of CAMS will be deployed over the next five years. (AF/LEYM)

CAMS is designed to improve weapon system availability, provide timely status and key historical data, streamline key maintenance management functions, and collect the data needed to achieve several of the new R&M 2000 objectives. It will replace the Maintenance Management Information and Control System (MMICS) over the next few fiscal years.

Implementation will be in seven increments:

Increment 1 converts the current batch maintenance data collection system to an on-line collection and work order generation system. The impact will be major reduction in the paperwork required of airmen and first-level supervisors. **Increment 2** provides an electronic interface between maintenance and supply for ordering parts and checking status. **Increment 3** is an automated aircraft debriefing system. **Increment 4** links the base personnel function to CAMS. **Increment 5** provides multiple status reporting for aircraft. **Increment 6** is a follow-on to the Comprehensive Engine Management System. Finally, **Increment 7** automates quality control/standardization programs and production scheduling.

CAMS is separate from the Phase IV computer replacement project but, since CAMS depends on Phase IV hardware, it must follow Phase IV implementation.



CURRENT RESEARCH

AFIT School of Systems and Logistics Completed Theses and Follow-on Research Opportunities

The Air Force Institute of Technology's thesis research program is an integral part of the graduate education program within the School of Systems and Logistics. The graduate thesis research program is designed to contribute to the educational mission of AFIT's Graduate Program through attainment of the following specific objectives:

(1) Give the student the opportunity to gain experience in problem analysis, independent research, and concise, comprehensible written expression.

(2) Enhance the student's knowledge in a specialized area and increase the student's understanding of the general logistics environment.

(3) Increase the professional capabilities and stature of faculty members in their fields of study.

(4) Identify military management problems and contribute to the body of knowledge in the field of military management.

Organizations that have potential research topics in the areas of logistics management, systems management, engineering management, and contracting/manufacturing management may submit the topics direct to the School of Systems and Logistics, Air Force Institute of Technology (Lt Col Gary L. Delaney, AUTOVON 785-3944/3809).

The graduate theses listed in this article were completed by Class 1984S of the Air Force Institute of Technology's School of Systems and Logistics. AFIT Class 1984S theses are presently on file with the Defense Logistics Studies Information Exchange (DLSIE) and the Defense Technical Information Center (DTIC).

Organizations interested in obtaining a copy of a thesis should make the request direct to either DLSIE or DTIC, not to AFIT. The "AD" number included with each graduate thesis is the control number that should be used when requesting a copy of a thesis from DTIC. The "LD" number should be used when ordering from DLSIE.

The complete mailing addresses for ordering AFIT graduate theses from DLSIE and DTIC are as follows:

DLSIE
U.S. Army LMC
Ft Lee VA 23801
(AUTOVON 687-4546/3570)

DTIC
Cameron Station
Alexandria VA 22314
(AUTOVON 284-7633)

CLASS OF 1984S THESES

Captain Jared A. Astin
Captain Christopher D. Ruff
*Determining Managerial Methods of Productivity
Measurement Within Civil Engineering Design
Units*

ADA146934
LD60566A

1Lt Mark H. Bailey
*An Investigation Into the Feasibility of
Establishing Manpower Standards for Major Air
Command Engineering and Services
Organizations*

ADA147111

Captain Roy Bousquet
*A Comprehensive Expedient Methods Field
Manual*

ADA146892
LD60568A

1Lt Timothy A. Byers
Major Susanne M. Waylett
*Measurement of Air Force Fire Department
Productivity: An Evaluation of
Efficiency/Effectiveness*

ADA146874
LD60670A

Captain James Cady
*Profile of a Successful Civil Engineering Career
in the United States Air Force*

ADA146873
LD60565A

1Lt Mark Correll
*Analysis of Training Needs for Civil Engineering
Superintendents and Foremen*

ADA147109
LD60672A

1Lt Carlos R. Cruz-Gonzalez
Captain Rodger G. Schuld
*Off-Base Facilities and Utilities: Threats to
Mission Accomplishment*

ADC035965
(CLASSIFIED)

1Lt Marvin N. Fisher
*Methodology for Measuring the Efficient Use of
Available Resources in Air Force Civil
Engineering Organizations*

ADA147110
LD60671A

Captain Jerry Haenisch
*Attribution of Base Civil Engineering Leadership
by Wing and Base Commanders*

ADA147182
LD60544A

Captain Robert Woods
Captain Marvin Harrison
*Development of Design and Economic
Parameters for Passive Solar Systems*

ADA147181
LD60682A

Captain Charles Howell
Captain James Konyha
*Investigation of Role Conflict and Role Ambiguity
for Junior Civil Engineering Officers*

ADA147113
LD60552A

Captain Mario W. Mastrangeli
*A Decision-Oriented Investigation of Air Force
Civil Engineering's Operations Branch and the
Implications for a Decision Support System*

ADA147065
LD60551A

Squadron Leader Kenneth Moschner
*A Study of the Relationship Between User
Attitudes and the Success of the MAJCOM and
AFRCE Work Information Management System*

ADA146956
LD60550A

Captain James T. Ryburn
*Cost Model Formulation for Estimating
Architect - Engineer Fees at Base-Level Civil
Engineering*

ADA146958
LD60678A

Captain Emmitt G. Smith
*An Examination of the Air Force Civil
Engineering's Prime Beef Home Station Training
Program*

ADA146957
LD60681A

Captain Timothy R. McLean <i>Improving PAVER Implementation</i>	ADA147727 LD60872A	<i>Assessment of Initial Technical Training for USAF Supply Officers</i>	
Major Harold Mashburn, Jr. <i>An Evaluation of the Education and Training of Marine Corps Combat Engineer Officers</i>	ADA147260 LD60683A	Captain Thomas Brown, Jr. Captain Dennis R. Lyon <i>United States Air Force Technical Order Acquisition: What Are the Problems and How Can They be Corrected?</i>	ADA146931 LD60675A
1Lt Douglas Tucker Captain Danny Van Dalsen <i>A Decision Support System for Bare-Base Planners</i>	ADA146959 LD60680A	Captain Charles L. Burdsal <i>Analysis of the Proposed Use of Minuteman Missile Combat Crew Members as Maintenance Extenders</i>	ADA146933 LD60679A
Captain Larry D. Abney Captain Robert E. Burtleson <i>Manpower Impact Assessment Model (MIAM): An Analytic Model for Assessing the Effect of Supply Policy Changes on Manpower Requirements at Retail Supply Activities</i>	ADA147557 LD60882A	Captain Parnell M. Campbell Captain Robert M. Gallagher <i>An Analysis of the Technical Training of Enlisted Minuteman Missile Maintenance Personnel</i>	ADA147078 LD60616A
Captain William K. Bass Captain David J. Schmitt <i>An Analysis of Causes of Contract Price Change for Competitive Procurements of Replenishment Spare Parts</i>	ADA147112 LD60673A	Captain Pia Caruso Captain Jeff Eisenberg <i>The Impact of Alternative Tariff Rates on Military Airlift Command Revenues</i>	ADA147714 LD60857A
Captain Peter A. Blatchley <i>An Evaluation of the Effect of a Quality Circle Intervention on Attitudinal Variables in Three DOD Organizations</i>	ADA147728 LD60856A	1Lt Joseph Codispoti Captain Michael McClain <i>Peace REMO II: USAF Commitment to Turkish Air Force Logistics Self-Sufficiency</i>	ADB087066 LD60558A
Captain Edmund Brodeur, Jr. Captain Karen W. Currie	ADA146932 LD60674A	Lt Jack E. Jones, USN <i>An Analysis of Constraints to Coordinated Tactical Crew Interaction in the P-3C Aircraft</i> (The conclusion of this listing will appear in the Fall issue.)	ADA147220 LD60556A

◀ FROM 23

The costs are summarized on "budget profile" reports. These give total dollar amounts across the categories of items. There are cases—especially with recoverables—that individual items may drive dollar amounts very high due to high unit costs. PRECOMP breaks out high cost items for analysts to study in association with detail reports.

PRECOMP also produces magnetic tape inputs for D033 (supply) and D040 (war readiness lists/requirements) that can drive the prepositioning of the DMSK. Both tapes are produced for the SOR being run. The tapes are input after review and editing by the SOR which is stocking its DMSK.

Adaptability and Interface With New Systems

The logistics "systems" world is undergoing modernization. AFLC is updating current methods by consolidating separate but complimentary computer systems. This evolution is recognized in the design of PRECOMP. DMSK computation and PRECOMP operations will continue to be integrated with new systems—especially the AFLC requirements data bank (RDB). As updated systems become the standard, PRECOMP can adapt easily by adjusting a simple formatting program on the front end of the model. If enveloped later into a system like RDB, its FORTRAN code and documented software will make it easy to absorb.

Current Status and Subsequent Operation

PRECOMP has been successfully run at Ogden ALC, its birthplace. The first DMSK computations, run in May 1985,

are the basis for the initial DMSK induction across AFLC. DMSK has been authorized by HQ USAF/LEY. Subsequently, the PRECOMP will be institutionalized at each SOR. Annual computations of DMSK will be run and the results will be consolidated at HQ AFLC for production of reports and review. After approval and editing, SORs will use output tapes to adjust DMSK levels. HQ AFLC/MMMR will provide each SOR with a special G072E war repair requirement or appropriate substitute (RDB, etc.). The centers will use their own current G005M and D033 data bases and the G072E tape as input to the PRECOMP model. Each SOR will send PRECOMP results to a central processing location where SSD recoverable computations will be completed by PRECOMP. Appropriate outputs will be transmitted to each prime manager.

Summary

Since depot production will significantly impact sustained sortie rates in projected conflict scenarios, SORs must have spare components on hand to support unprogrammed surges in repair demand. The PRECOMP model will compute DMSK levels while accounting for POS and split repair requirements. User-tailored reports and automated networking to AF standard supply and WRM systems will facilitate introducing this kit at the SORs. The increased levels of components in the DMSK will provide greater probability of prompt repair of carcasses and their quick return to the field. This will enhance the replenishment of field supplies and ultimately allow increased sortie production.



Assessment of Risk: A Technology Transfer Challenge

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A major technology transfer challenge is assessment of the risk associated with providing technology and equipment to other nations. To assess risk one must weigh policy, the relative level of technology, and the end-use. Incorporation of "dual-use" technologies further complicates the risk determination. However, to provide more realistic, defensible Air Force positions, each area must be addressed by all who review technology transfer requests. With the growing list of internationally desired technologies, virtually any Air Staff, major command, field unit, or system program office expert may be tasked to assess risk in a specific area of expertise. A basic understanding of risk assessment is therefore a valuable addition to the logistician's cache of collateral talents.

Technology transfer requests may come through foreign military sales (FMS) channels or may be strictly commercial transactions. But, regardless of the flow of paperwork and final approval authority, *risk assessment* is the bottom line in any decision or recommendation on release of technology.

There are many answers to the basic question of what constitutes technology transfer, depending on who is asked. Therefore, for the purpose of this paper, "technology transfer" will include export or release to a foreign country (East or West) of any technical data, equipment, manufacturing processes, or other goods or information.

My perspective on technology transfer is that of an Air Staff action officer (AO) evaluating individual requests, and my specific remarks and questions come from this perspective. The important point is the concerns represented by those questions are broad—far broader than an individual AO's responsibilities or expertise—and we must share our knowledge, expertise, and insights in all facets of the assessment process.

There are many difficulties with risk assessment. Some are inherent to the nature of the process and probably cannot be readily changed. Risk assessment is imprecise at best, based on one's judgment, evaluation, supposition, guess, or expectation of what another may do. Any risk assessment is a probability of some particular occurrence and the probable result or cost of that occurrence—in this case, the probability that a specific technology transfer will adversely affect the United States military posture or the national security. Although there may be other broader concerns, the focus of Department of Defense (DOD) involvement is in evaluation of technology which may have a direct or indirect military end-

use. But determining what military enhancement or advantage a transfer may provide the recipient is difficult. This is particularly true for technologies with dual-uses (military and commercial) or indirect military application. If we can find a way to decrease the difficulty of this assessment, the final Air Force recommendations will be both more realistic and more defensible.

We must first recognize that risk assessments change—what is valid today may be far off the mark tomorrow. Risk assessments must be continually refined and revalidated. Correct, up-to-date information is the cornerstone of this process. The information needed for this determination spans the waterfront of military, technical, and policy issues—this requirement poses the greatest problem for the reviewing AO and perhaps provides the largest potential for improvement.

Policy Concerns

The first input must be policy. Although policy changes (sometimes quite dramatically), the general tone or policy is easy to discern if we are talking about communist bloc countries. However, it may not be so easily recognized for other nations. And if the general thrust is not readily apparent, imagine determining the specific policy for any given country. What, for instance, is the current export policy towards South America in general, or any one of those countries specifically?

To complicate matters further, policy may vary among FMS requests, munitions cases, and commercial export of dual-use items having direct or indirect military application. Moreover, the policy may be interpreted differently among the various reviewing agencies, departments, or offices.

Among the policy-related questions which must be answered are:

- (1) Is the foreign country a treaty ally, a NATO partner, a favored nation, an important trading partner, or a neutral country with whom we wish to maintain or enhance our standing?
- (2) Does current policy encourage us to be forthcoming and somewhat liberal in our recommendations or is it the other way around?
- (3) Is the request related to any specific memorandum of understanding (MOU) or agreement (MOA), co-production agreement, or other formal cooperative arrangement?
- (4) What are the general or specific disclosure guidelines relative to this technology, item, or product?
- (5) Is there any specific embargo on exports of this technology or to this country?
- (6) Are there any specific end-uses and/or end-users that have already been determined to be acceptable, or unacceptable?

Policy guidelines are not necessarily broad, general statements which lend themselves to endless interpretation and reinterpretation. Sometimes, they are very specific technical limits on capability or capacity beyond which release is not generally authorized. Regardless of form, guidelines are desirable in order to ensure a recommendation which is

consistent with current policy, as all other considerations must be weighed against this basic framework. If a recommendation is not properly "built" around this framework, the result may be rather shaky and, in some cases, structurally unsound.

Technical Considerations

A second area in which information is required is the technical one. Evaluating the technical risk is probably the most difficult piece of the equation. Perhaps this perspective is not universal, but my field of computer technology is extremely broad, pervades military systems, and is rapidly changing. The added potential for military application of systems with legitimate civilian end-uses can make the equation extremely complex.

Answering the question, "What is the relative level of technology incorporated in or represented by the item?" is crucial to a valid technical assessment. To do this, we must have a broad understanding of the current level of development of that technology—what is old, what is widely available, and what is just emerging from research and development (R&D).

Just knowing what is happening in the US is not sufficient. One must also judge the foreign availability—both quality and quantity—of comparable technology. If we do not recommend approval of the request for the desired item, can it be obtained elsewhere, possibly from the French, the Israelis, the Japanese, or the Swedes? Perhaps such a determination is easy in case of aircraft, missiles, tanks, and guns. But a computer-controlled air defense or range safety system represents a multi-layered problem of considerable complexity, since the major components may be commercially available dual-use technologies of individually varying levels of sophistication which collectively comprise perhaps a still different level of overall capability. One needs to consider the foreign availability of comparable computer systems, graphic displays, and sophisticated software. Is the computer old and widely available or is it new and state-of-the-art? Is the system uniquely packaged and therefore worth protecting irrespective of the individual components?

Once the relative level of technology and its availability have been put in context or perspective, still other questions remain:

- (1) What is the impact, positive or negative, of others possessing or sharing this technology?
- (2) What is the potential for reverse engineering?
- (3) How would the US counter a disclosure or upgrade current capabilities beyond the level represented by this item?
- (4) What would be the direct or indirect cost (dollars, time, effort) to do so?
- (5) How much and what kind of impact would this transfer have on the capabilities of the foreign recipient?

None of these questions are easily answered. Sometimes answers are not possible. But, at the very least, each question must be considered.

Potential Uses of Transferred Technology

Once policy and technology have been addressed, there is one last major area which must be scrutinized—the functional one. With aircraft, tanks, or other significant military items, the end-use is generally well-defined; the actual use can often be easily tracked; and the potential for diversion to other uses is limited. On the other hand, smaller military items (guns) and dual-use technologies (computers and microelectronics) have

many end-uses. Thus, each request requires an assessment of the reasonableness of the end-use. And if the end-use is acceptable, is the proposed solution sized to fit the problem? For example, is the proposed computer-aided design system appropriate for automatic production of drafting documents or is it more suitable for interactive design of an entire ship, aircraft, or missile? Is the proposed computer a large mainframe when a small word processor could do the job?

While considering end-use, the question of enhancement of other related functional areas must also be addressed. For example, a commercial railway scheduling system could serve equally well a real-time military logistics function or an operations planning function. Are other end-uses reasonable or likely given the political, economic, or social climate in the foreign country? What is the likelihood of that diversion? Of reverse engineering? Do we even care? And if we do, would the technology receive sufficient safeguards to obviate any concerns? Alternate end-uses must be considered and the enhancement such alternatives provide weighed. However, determination of alternative uses or functions is difficult because each of us has our own expertise and functional biases built through experience. Identifying the other potential end-uses may call for some creative thinking; even so, appropriate questions or alternative scenarios may go unrecognized.

Clearly, recommendations for or against approval of any specific request cannot be made in a vacuum. All three areas must be considered by each reviewer prior to a recommendation on release. But, even though the need for this consideration reaches down to each AO who reviews export requests, not all the questions can be adequately addressed by every AO. Some considerations presume a broad understanding of the technical, political, or functional implications (and associated potential positive and negative effects) of any specific course of action—a perspective which is sometimes better in the specific responsible staff or at higher levels. Each staff office and approval level looks at the request from a different perspective and that is as it should be. But, just as many questions and concerns overlap all three areas and do not fit neatly in any one, *each* reviewer, not just those from the policy offices, must consider policy. *Each*, not just the functional users, must consider the end-use. The final Air Force recommendation must be an integrated appraisal which fairly considers all three.

In the end, one final question must be answered: Is the recommendation realistic and the position defensible? Our positions must be able to withstand scrutiny from the contractor or manufacturer, the requesting nation, and other interested parties. We must be able to rationally and reasonably articulate and defend our concerns and assessments. We must not find ourselves in the awkward position of being shown that we have erred in our assessment of the risk. Our credibility rides on fairly implementing Air Force, DOD, and US policy, while safeguarding the militarily critical technologies, equipment, and processes which are crucial to our national security.

Technology transfer controls play an important part in supporting the US national security. Recommendations on export of US technology require an assessment of risk based on policy, level of technology, and functional use.

The challenge we face is developing realistic, defensible recommendations which safeguard our military posture while withstanding outside scrutiny.

"This paper reflects the views of the author and does not imply Department of Defense endorsement of factual accuracy or opinion."

6 Strategic Thinking and Logistics

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During our Air Force careers, we have all been involved, to varying degrees, in planning and executing exercises and real world contingency operations. We tend to follow carefully developed operating plans placed on the shelf and periodically updated by the unified and specified command staffs whose attentions are focused on specific geographical areas of potential conflict. We *presume* the senior members of those staffs, as a result of their operational experience and professional military education (PME), have solid foundations in United States (US), allied, and enemy doctrine and strategy.

Unfortunately, that may not be the case. I have seen too many officers, responsible for battle staff decision-making, who seem to have trouble fully grasping doctrinal, strategic, and force employment issues. While they are strong in the areas of force readiness, force posturing, and deployment, they often count on the Joint Chiefs of Staff (JCS), theater commander, joint task force commander, or someone else to formulate war-fighting strategy and make employment decisions. Most of these officers are equipped with PME, which has stressed leadership, management, staff writing, speaking, and other skills. While this type of education is important for a well-rounded officer, the amount of curriculum time spent in the study of *enemy doctrine and strategy* pales by comparison. These issues are dealt with in our PME programs only in passing and in not much depth. The approach seems to be that officers will absorb these things by osmosis, in an on-the-job training (OJT) mode, during the course of their careers.

We are, for the most part, counting on our strategic thinkers and airpower strategists to pick up these crucial skills "on the run!" And for those of us who believe in career broadening, i.e., working at different levels in numerous commands dealing with diverse problem sets, it is particularly difficult to be well-versed in any specific geographical area or in any potential enemy's capabilities, much less in the complex problem sets associated with the employment of airpower in those areas.

The tremendous diversity of potential battlefields presents the Air Force with a challenging and complex mission. We must be prepared to fly and fight effectively in a high intensity NATO/Warsaw pact conflict, both in the central region and on the flanks. We must be able to deploy and employ airpower in the distant Persian Gulf, against a superpower rival, and operate in his strategic backyard. We must be ready to employ airpower on short notice in Korea. We may have to employ air forces in Lebanon or in North Africa against an unpredictable Libya. And, the possibility of employing airpower in our own hemisphere cannot be discounted, as in Grenada. Scenarios can also be envisioned in Nicaragua or El Salvador. How does one prepare for such a wide variety of missions across the spectrum of conflict and in many different locations? Though this is not a problem for the military officers of most nations around the world, it is certainly something Air Force officers must think deeply about.

"The enemy is likely to choose the time and nature of the next conflict and leave us without the luxury of time for strategic thinking after the balloon goes up."

If we are to effectively employ airpower to support diverse US national interests, we must prepare ourselves to do some hard *strategic thinking*—we must fully understand US, allied, and enemy doctrine. We must learn something of the military history, force structure, and mindset of any potential enemy. We must also learn not to plan in a vacuum and disregard actions the enemy might take to impede our operations. Most importantly, we must not assume someone "higher up" or "over there" is going to do our strategic thinking for us. The enemy is likely to choose the time and nature of the next conflict and leave us without the luxury of time for strategic thinking after the balloon goes up.

What does all this have to do with logistics? It has been my experience that logistics is *key* to the success of any military operation. Greater military figures than myself have shared this view. Unfortunately, many of those greater military figures reached that conclusion in hindsight. Napoleon had his problems in Russia, the Germans suffered a logistics nightmare trying to execute the Von Schlieffen Plan in World War I, and MacArthur came up a bit short in the Philippines. As we look at the potential battlegrounds of tomorrow, and the distances we shall have to cover delivering beans and bullets to them, we would do well to ask if the misfortunes of these past warriors could hold harrowing hints of our own strategic future.

For example, Air Force logisticians have probably been told that the Navy will move the bulk of their military forces and supplies to distant trouble spots. In terms of load capabilities, this theory seems sound. However, as in most military situations, this will be scenario dependent. In a NATO/Pact war in Europe, for instance, the Soviets are well aware of our requirement to rapidly reinforce by sea. With their sizeable submarine force, they might be able to flush a significant number of attack submarines into the Atlantic prior to hostilities. Their air and unconventional warfare forces will target US European port facilities. One might also ponder the ability of surface forces to ensure a logistics flow through a contested Mediterranean Sea to NATO's southern flank and through an embattled Norwegian Sea to NATO's northern flank. And what of other theaters?

Anyone who has studied the Persian Gulf situation knows that supplying US ground forces in Iran by sea could be extremely difficult. The Soviets possess the greatest minelaying capability in the world. They can deliver mines by air and submarine, making the strategic Strait of Hormuz extremely vulnerable. Their ability to close, or impede the flow of war materiel through, the Suez Canal and the Bab el Mandeb Strait should not be doubted.

Even a casual student of Korea may have noted North Korean progress in developing a growing submarine force, designed for interdiction of our sea lines of communication (LOC). That, together with increasingly potent naval commando and airborne commando forces, will present US and Republic of Korea (ROK) commanders with a serious rear area protection (RAP) problem affecting both routes and ports.

Of course, I am familiar with prepositioned supplies and equipment in Europe, Korea, and the Persian Gulf region. While this is a partial solution, and certainly a prudent step, the enemy is also familiar with these caches. Since camouflage, cover, and deception have never been our strong suit, we must ask ourselves if we are taking enough precautions and concentrating enough initiatives in this area. Besides denying the enemy locational intelligence on those critical stores, what emphasis is being placed on ground and air RAP from unconventional warfare (UW) operations and air attack?

In the face of such impedance in our naval supply capability, it is the business of Air Force logisticians to assume that some critical manpower, munitions, and supplies will *have* to be moved to distant combat locations by *air*. As strategic thinkers, are we asking the right questions? Are we disregarding some obvious complications? Are we guilty of wishful thinking?

There are numerous variables to consider when looking at airlift logistics support of NATO in a European war. The Soviets will decide the general timing of an attack. They will use the weather to their advantage. They live and work continuously in a harsh climate, by our standards, and they train to fight in bad weather. "Father Winter" has been a Russian military ally more than once in the past. Poor weather can make both strategic and tactical airlift operations difficult in a high intensity combat environment. Also, the Soviets are determined to engage in radio electronic combat (REC), and they will make every effort to degrade our C³ and tactical communications. They are students of our rapid reinforcement exercises and logistics layout and requirements. Their doctrine calls for disrupting our airfields to deny or degrade critical reinforcement. Their growing numbers of surface-to-surface missiles and SU-24 Fencer fighter bombers are increasing their offensive counter air capabilities to attack those airfields and alternates.

Faced with the possibility of poor weather conditions, limited communications capabilities, and damaged airfields in the NATO rear, we must ask ourselves if we have identified enough locations where strategic aircraft could land and if we could adequately position, control, and protect the people, equipment, and ground transportation needed to handle a sustained flow to such locations. What capabilities do the C-5 and C-141 have to operate from unimproved airfields? Are our crews being trained in peacetime to perform such missions? What is our Civil Reserve Air Fleet (CRAF) capability to operate in this fashion? Having chosen some preplanned, alternate, unimproved locations, and trained to operate from them, do we have air defense equipment and security forces committed to protecting them? How are MAC crews and our logistics people trained and equipped to operate at these locations in a chemical and nuclear environment? Might we not expect such locations, once known to the enemy, to be targeted with perhaps first chemical and then nuclear weapons?

If one looks at Soviet unconventional warfare or Spetznaz forces today, and their doctrine and equipment, one must be concerned about the SA-7 threat to MAC and CRAF crews in the NATO rear. We must ask if MAC and CRAF crews have the equipment and training necessary to avoid enemy naval forces operating in an emission controlled, passive detection mode, so we will be able to avoid flying into a naval surface-

to-air missile (SAM) envelope. Soviet carrier air, such as air-to-air missile equipped Forgers, may threaten the airlift force. Airlift aircraft and tankers may be vulnerable to long-range Foxhounds, under airborne warning and control system (AWACS) control, feet wet over the Norwegian Sea or the Mediterranean. The Soviets may attempt to extend the range of their land-based fighters by operating from captured airfields in northern Norway and on NATO's southern flank. If you were them, wouldn't you? If NATO air superiority is questionable over Norway and Turkey, can we use strategic aircraft to airdrop or perform low altitude parachute extraction system (LAPES) deliveries to minimize exposure to the threat? How much training do we have in performing such missions with our high speed strategic airlift aircraft? If we require US Navy, Air Force, or allied fighter escort for our airlift forces, are we training in a joint and combined environment to perfect such operations?

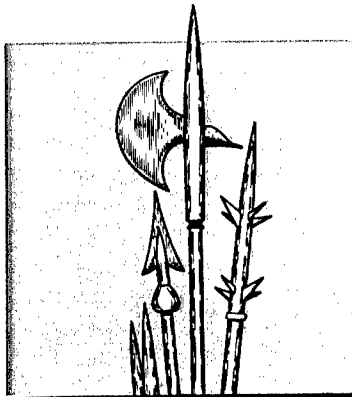
Many of the same questions apply equally to the logistics nightmare of the Persian Gulf. We must be concerned with host nation ground security and air defense capabilities throughout the Gulf littoral area. The Soviets may employ airpower from Afghanistan; they may extend their airpower to captured airfields as they move south; they may employ AWACS and long-range fighters in this theater; they may employ Spetznaz forces in our rear areas; and they may use airpower to interdict our air LOCs over the Indian Ocean and elsewhere. Will the US Navy move carrier battle groups into the restricted waters of the Gulf for employment in the air campaign or will the Air Force fight alone to support our troops and keep the air LOCs open?

In Korea, our air superiority may be in less question, but can we count on it? Considering the air and sea commando threat to rear area security, the possibility of North Korean Air Force (NKA) air attacks occasionally, and the value of our strategic airlift assets, we may want to minimize ground times in the ROK. Also, if we assume Soviet backing for North Korea, is it likely the Soviet Air Force and Navy will provide intelligence and possibly vectoring data on our airlift routes? The SA-7 threat will also apply in ROK rear areas. If we were North Korean strategists, concerned about rapid aerial reinforcement, what strategy would we use with a weapon like the SA-7?

"Logisticians must be airpower strategists in their own right."

Logisticians must be airpower strategists in their own right. They must influence the planners, operators, and decision-makers. They must talk with the intelligence folks to pick their brains and share concerns. As an intelligence type, I would like to forget the number of times I have asked the operators why they had made such a deployment or employment decision, only to be told that it was the only way the loggies could support it! Can we work a compromise? Because if we cannot, those aircraft are going to draw the enemy like a magnet!

Logisticians must learn to be *strategic thinkers* and ask the right questions in order to meet future challenges. This is the only way to ensure we will be ready to respond when called.



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MOBILIZATION IN LIMITED WAR: VIETNAM

"The force structure of the active duty components of the Armed Forces must be designed to permit adequate logistic support of ready forces in quick reaction to emergency situations. During peacetime, emphasis was in some cases placed on the maintenance of combat and combat support forces without adequate combat service support units and trained technical personnel. As a consequence, when contingency operations are undertaken and the Reserves are not called up, serious deficiencies in logistic units and trained logistic personnel may be expected. There is a need, therefore, to enhance readiness to respond promptly to limited war of scope comparable to the Vietnam conflict without reliance on national mobilization or callup of Reserves to conduct logistic operations."

From: *Logistics Support* by Lt Gen Joseph M. Heiser, Jr.

PROJECT SPECIAL EXPRESS: VIETNAM

"The pipeline for munitions was based on maintaining a 30-day supply at the forward bases and a 120-day supply in the Philippines. It also took an average of 90 days to replenish the munitions depot at Clark and another 24 to 35 days to move the munitions to South Vietnam. As a result, a seven- to eight-month supply of munitions was often tied up in the supply pipeline. It soon became apparent to both AFLC and PACAF that something would have to be done to expedite the flow of munitions to Southeast Asia.

In January 1965, Headquarters AFLC asked Air Force headquarters to approve a plan that had been developed by AFLC and PACAF for accelerating the delivery of munitions to South Vietnam. In general, this plan called for using five ships which would be dedicated to moving munitions from the United States to South Vietnam. . . . PACAF requested that the Special Express program be expanded to 10 ships. AFLC dispatched a team to Southeast Asia to study the matter at first hand. This review and the Ogden Air Materiel Area's analysis led AFLC to conclude that it could support PACAF's proposal for two separate Special Express systems with five ships assigned to each one. The expanded program would allow the Air Force to maintain a 120-day supply of munitions in the general area of the forward bases, a 90-day supply on the ships, and a 30-day supply at the storage sites.

By the middle of March 1966, the Special Express program had been expanded to 15 (eventually 19) ships which were divided into three groups. The first, or ALPHA, group consisted of six ships which stopped at Qui Nhon, Nha Trang, and Saigon. The second, or BRAVO, group also consisted of six ships, and its ports of call were Cam Ranh Bay, Da Nang, and Phan Rang. The third group, called COCOA, consisted of three ships which supported the Air Force's munitions requirements in Thailand.

AFLC did not use the Special Express system to support SAC's munitions requirements in Southeast Asia because SAC did not need the floating storage or selective discharge features of the system."

From: *Logistics: An Illustrated History of AFLC and its Antecedents 1921-1981*, HQ AFLC.

BATTLE OF THE BULGE LOGISTICS

"One reason the counteroffensive failed was that German combat service support, transportation in particular, did not keep up with the advance of combat formations. While it is true that the German munitions production had waned since 1939, the Fuehrer's troops ran out of ammunition not because there weren't enough shells at the Rhine dumps but because the ammunition didn't make it to the front. Loss of trucks due to battle damage and mechanical failure had been heavy throughout 1944, so heavy that new production could replace only half the losses. Some units were equipped almost solely with confiscated vehicles, which had to be abandoned upon mechanical failure for lack of repair parts

These transportation problems alone were enough to preclude successful supply support for tactical operations of the Wachtam Rhein. To make matters worse, Germany still made extensive use of horses for transport. Traveling over treacherous, shelled, snow-covered roads during a season when forage was not readily available, many sickened and died.

Unlike the supply vehicles of Germany, those of the U.S. Army were seldom impeded by road blocks and traffic jams. Furthermore, U.S. logistical and tactical moves were not subject to harassment or attack from the air. Many American divisions had sufficient vehicles to carry their supplies; others were available through line-of-communications sources. The much-criticized size of the U.S. logistics "tail" paid off during the Ardennes Campaign, for in contrast to Germany, there were always enough transport resources to satisfy demands for troop and supply movement.

Fuel supply presented particular problems for the German Army. Like all other supplies, fuel did not move as quickly as the armored advance. Nor had German planners anticipated that bad terrain and inclement weather would reduce by one-half the mileage-per-tank consumption figure they had projected. Furthermore, the German attackers did not capture nearly as much enemy fuel as they had hoped. During the first week of the counteroffensive, the petroleum shortages experienced by the German Army were caused mainly by transportation problems, bad roads, traffic congestion, and vehicle failure. After 23 December, when the weather cleared, fuel supply was impeded by Allied bombings of roads and German supply points.

In contrast, U.S. Army units never experienced serious fuel shortages, even though they had to move, destroy, and occasionally abandon fuel supplies. Despite their possession of a map of American POL installations, the Germans captured no more than several hundred thousand gallons of petroleum

Problems in maintenance, which in combat is dependent on transportation for the recovery of vehicles, also plagued the German Army. There was a shortage of tank retrievers, and after 23 December the few that were available became the target of Allied fighter-bombers. Consequently, the high German tank losses can be attributed as much to mechanical failure as to battle damage. Only six tank repair companies deployed to the front, and the spare parts situation became so critical that new German tanks were cannibalized at a depot west of Koblenz.

Americans had few major maintenance problems. Initially, a few ordnance companies were overrun, but most tank maintenance

personnel and equipment were moved safely out of enemy range and continued to function effectively. Many medium tanks were lost from battle damage, especially during the first 2 weeks of the offensive, but these losses were filled by diverting tanks that had been allocated for British use."

From: "Logistics of the Battle of the Bulge," *Army Logistician* (Jan-Feb 85).

WATER AT ALAMEIN: 1942

"Rommel's water supply always was a headache to him at Alamein . . . over 1,000 of his men had deserted because they were dying of thirst. He surmounted that first dire emergency by loading some schooners with water at Tobruk and beaching them behind his line at Alamein. Then he developed some wells at Fuka, where underground water was plentiful. From Fuka he used our pipeline to pump the water eastward as far as Sidi-Abdel-Rahman, just behind his battle line.

That use of my pipeline irked me. In one way, however, it eventually turned out to our advantage. To pump water through that pipeline the German sappers had to repair the damage done in demolition by our engineers during the retreat. In the great surge forward after the final Alamein battle I was to find that the Germans had done their repair job well, but that the speed of their own retreat had precluded their doing much demolition themselves. Consequently I found that section of the pipeline which the enemy had used almost in even better repair than we had left it."

From: *Pipeline to Battle* by Maj Peter W. Rainier, Corps of Royal Engineers.

SUPPLYING THE TROOPS

"Enormous supply lines slowly came into being as the American Expeditionary Forces, finding that the French could not provide adequate ports or railroads or camps or warehouses, began building its own on a scale theretofore unprecedented. All this involved much manpower; Pershing estimated that of the first million men that arrived in France no more than five hundred thousand would be available for the front lines. Thus it was that hundreds of thousands of men found themselves assigned to the Services of Supply, filling vital needs but seldom seeing active combat. Major General James G. Harbord, who was in command of the S.O.S. in the final months of the war, has paid tribute to the officers and enlisted men who filled its ranks:

"By far the great majority of the officers and men who wore the shoulder insignia of the S.O.S. were fresh from civil pursuits. They came from every walk of American life and from every field of its business. The sacrifice at which they served could be measured by the energy and intelligence which they gave to their duties in the knowledge that the more they gave, the sooner the War would be ended. We were engaged in what was relatively a civil task, compared to combat. Far from the sounds of the drums and the guns; unsought by the glory-hunters; absent when promotions were being distributed; ineligible even at the price of life itself for the medals that reward heroism in action; doomed to spend the rest of their lives explaining why they served in the Services of Supply—their equal in trained intelligence and general fitness for their tasks could not have been found in any other land than the one for which they so truly fought. Such men may not have been within range of the enemy guns but they did more for their country by living for it than they could possibly have done by dying for it.' "

From: *Over There* by Frank Freidel.

Summer 1985

"The final dictum of history must be that whatever excellence Lee possessed as a strategist or as a tactician, he was the worst Quartermaster-General in history, and that, consequently, his strategy had no foundations, with the result that his tactics never once resulted in an overwhelming and decisive victory."

Major General J. C. Fuller

ROOTS OF CURRENT POLICY

"The fundamental logistical problem for the Air Materiel Command was to be able to support military forces at the same speed with which they could be employed tactically or strategically. During World War II it had become painfully apparent that the mobility of air power was too often shackled by the limitations of surface logistics, stodgy communications technology, and manual record-keeping. In mid-1945, delivery of an item requisitioned by U.S. forces in Germany took an average of 106 days. The advent of jet aircraft made the disparity between supply and striking speed even more acutely frustrating. Moreover, the long pipeline time meant that more items had to be purchased to fill it, consuming budget dollars that were needed for other purposes. The Air Materiel Command elected to attack this sluggishness with the weapons of airlift in combination with automation in its various forms—electronic data processing, communications, inventory control, material handling, and manufacturing methods.

Many of the policies and actions which the Air Materiel Command undertook during the period following the Korean War had their origins in the concept known as "Logistics for 1956," which was generated by Air Force headquarters during the early 1950s and endorsed by the Chief of Staff in February 1953. This package of ideas called for ending the practice of prestocking supplies overseas, reducing the work load at overseas depots, and reducing the amount of materiel which was in the supply pipeline at any given time. The objective was to place as much of the peacetime stocks as possible in the hands of the operational commands, with the remainder located where they could be made available promptly."

From: *Logistics: An Illustrated History of AFLC and its Antecedents*, HQ AFLC.

COLD WEATHER LESSONS RELEARNED

"It could only have been in total ignorance of the Arkhangelsk campaign more than twenty-two years earlier that the German Army in 1941 could be 'surprised' (as General Rendulic expressed it) that because of the extreme cold the mechanisms of rifles and machine guns, and even the breech blocks of artillery, became absolutely rigid. The recoil liquid in artillery pieces also froze stiff, and tempered steel parts cracked. Strikers and striker springs broke like glass.

Soviet weapons were designed for winter, and they used appropriate lubricants. The Germans preferred the Soviet submachine gun to the model originally issued to them. During the first winter the Germans had to improvise by lighting fires under their artillery, and by either wiping off all the lubricants from weapons or experimenting with substitutes. Kerosene worked, but it was not durable and thus had to be renewed frequently. Sunflower oil proved quite effective, but it was available only in southern Russia.

From: *Leavenworth Papers* (No. 5) by Dr. Allen F. Chew.

“At the core of the affordability question is supportability. The Advanced Tactical Fighter’s (ATF) reliability and maintenance (R&M) goals are as important as the performance goals. Even at concept definition, reliability and maintenance goals are being defined. For instance, the sustained sortie generation rate has to be at least twice that of the F-15. Mobility requirements are specific. Whereas, to move a squadron of F-15s takes between 15 and 17 C-141s, the ATF goal is eight. The fighter will be designed to require fewer maintenance personnel and less support equipment. It may eliminate the need for avionics intermediate stations. Reliability improvements include built-in-test and on-board fault detection and isolation. Its engine, now in demonstration/validation, will have 40-60% fewer parts, and a 100-300% increase in reliability.”

General Lawrence A. Skantze, Commander
Air Force Systems Command

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